Multi-Phased Remedial Investigation (RI)
of Surface and Subsurface Contamination of Soldier Creek
at Tinker AFB, Oklahoma
U.S. Air Force Installation Restoration Program

FINAL

RECORD OF DECISION
SEDIMENT AND SURFACE WATER
OPERABLE UNIT

AUGUST 1993

TINKER PROJECT NO: WWYK89-0196B
SITE ID NO: TINKER OTO3

Contract No.
DACA56-89-C-0062

WASTE SCIENCE AND TECHNOLOGY CORP.

SOLDIER CREEK RI/FS (NPL Site)
Prepared for: Tinker Air Force Base through
U.S. Army Corps of Engineers
Tulsa District

FINAL
RECORD OF DECISION
TINKER AFB - SOLDIER CREEK
SEDIMENT AND SURFACE WATER
OPERABLE UNIT

Prepared for:
TINKER AIR FORCE BASE
through
TULSA DISTRICT CORPS OF ENGINEERS
CONTRACT NO. DACA56-89-C-0062

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AUGUST 11, 1993

Prepared under:
INSTALLATION RESTORATION PROGRAM
TINKER PROJECT NO. WWYK89-0196B
SITE I.D. NO. TINKER 0T03

RECORD OF DECISION
DECLARATION

SITE NAME AND LOCATION

Soldier Creek Sediment and Surface Water Operable Unit
Tinker Air Force Base (AFB)
Oklahoma County, Oklahoma

STATEMENT OF BASIS AND PURPOSE

This Record of Decision (ROD) presents the selected remedial action for the Soldier Creek Sediment and Surface Water Operable Unit of the Tinker AFB (Soldier Creek/Building 3001) Site, in Oklahoma County, Oklahoma, chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and is consistent, to the extent practicable, with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record file for the operable unit.

The State of Oklahoma concurs on the selected remedy. A letter of concurrence from the State of Oklahoma is presented in Appendix B.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this operable unit, if not addressed by implementing the response selected in this ROD, may potentially present an endangerment to public health, welfare, or the environment. However, the baseline risk assessment, including a qualitative environmental assessment, conducted for the operable unit concluded that Soldier Creek sediment and surface water do not pose a risk to human health or the environment in excess of the acceptable risk-based exposure levels established by the U.S. Environmental Protection Agency (EPA).

DESCRIPTION OF SELECTED REMEDY

Soldier Creek Sediment and Surface Water is an operable unit at the Tinker AFB Site. This ROD addresses the sediment and surface water contamination associated with on-base and off-base portions of Soldier Creek. The first ROD addressed the Building 3001 Operable Unit and consisted of identifying the sources of groundwater contamination and the threat posed by the migration of this contamination to the groundwater below Building 3001. The first ROD also addressed Pit Q-51, the North Tank Area, and Water Wells 18 and 19. A subsequent ROD will address potential groundwater contamination associated with the Soldier Creek Groundwater Operable Unit.

A limited action remedy has been selected for the Soldier Creek Sediment and Surface Water Operable Unit based on the Administrative Record. The baseline risk assessment determined that Soldier Creek sediment and surface water do not pose a risk to human health and the environment in excess of the acceptable risk-based exposure levels established by EPA. The remedy selected for the operable unit incorporates the following components:

- Five-year monitoring program of Soldier Creek sediment and surface water at on-base and off-base locations.
- Ecological investigation (quantitative and qualitative) of Soldier Creek sediment and surface water to further define the risk to the environment.
- Yearly monitoring report.
- Five-year review.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this operable unit. CERCLA provides a statutory preference for remedies which use treatment as a principle element of the remedy. However, as it has been determined that treatment is not necessary, it will not be used at this operable unit.

This remedy will not result in hazardous substances remaining in the creek sediment or surface water at concentrations greater than the health-based levels. A review will be conducted after five years to ensure that the remedy continues to provide adequate protection of human health and the environment.

_____ _____

Deputy Assistant Secretary of the Air Force (Environment, Safety, and Occupational Health) — Date

_____ _____

Assistant Administrator/Regional Administrator, U.S. Environmental Protection Agency, Region 6 — Date

TINKER AFB - SOLDIER CREEK
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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cm^2	Square centimeter
cm/hr	Centimeter/hour
COC	Contaminant of concern
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FS	Feasibility Study
HI	Hazard Index
HQ	Hazard Quotient
IWTP	Industrial Wastewater Treatment Plant
kg	Kilogram
L/day	Liter per day
L/kg-day	Liter per kilogram per day
LDR	Land Disposal Restriction
mg/cm^2	Milligram per square centimeter
mg/kg	Milligram per kilogram
mg/kg-day	Milligram per kilogram per day
mg/L	Milligram per liter
NAAQS	National Ambient Air Quality Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NA	Not Available
ND	Not Detected
NPL	National Priorities List
O&M	Operation and maintenance
OSHA	Occupational Safety and Health Act
OSDH	Oklahoma State Department of Health
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
ppm	Parts per million
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RI	Remedial Investigation
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SSW	Sediment and surface water

ug/L	Microgram per liter
ug/kg	Microgram per kilogram
WQS	Water Quality Standards

DECISION SUMMARY

1.0 SITE NAME, LOCATION, AND DESCRIPTION

The Tinker Air Force Base (AFB) Site has been divided into three operable units, Building 3001, which includes the groundwater below Building 3001, the North Tank Area, Pit Q-51, and Water Wells 18 and 19; Soldier Creek sediment and surface water; and Soldier Creek groundwater. This Record of Decision (ROD) addresses the Soldier Creek Sediment and Surface Water Operable Unit. The Soldier Creek Sediment and Surface Water Operable Unit is referenced in previous documents as the Soldier Creek Site. A comprehensive discussion of the site background is provided in the Remedial Investigation (RI) report. The RI is available in the Administrative Record file at the Midwest City Public Library.

1.1 Site Location and Description

Tinker AFB is southeast of the Oklahoma City metropolitan area, bordering on Del City and Midwest City in Oklahoma County. The Base is bounded by Sooner Road to the west, Interstate 40 to the north, Douglas Boulevard to the east, and Southeast 74th Street to the south, as illustrated on Figure 1-1 (page 1-2). The property boundaries of Tinker AFB are shown on Figure 1-2 (page 1-3). The main portion of Soldier Creek is to the east of Tinker AFB; however, two unnamed tributaries (East and West Soldier Creeks) originate on the Base. Soldier Creek flows to the north from its headwaters near Southeast 59th Street to its confluence with Crutcho Creek approximately six miles downstream. According to the Federal Facility Agreement (FFA) for the Base, the Soldier Creek Operable Unit includes Soldier Creek, its tributaries, and any area underlying or adjacent to the waterway that may be contaminated by the migration of hazardous substances, pollutants, or contaminants from Tinker AFB. The primary study area for this operable unit consisted of the tributaries that directly receive discharges or runoff from Tinker AFB (West and East Soldier Creeks) and the main stem of Soldier Creek from its headwaters downstream to East Reno Avenue, as illustrated on Figure 1-2 (page 1-3).

1.2 Site Demography and Land Use

Approximately 20,000 individuals work at Tinker AFB, of which 8,000 work at the Building 3001 complex. Tinker AFB accommodates 530 family housing units and 7 dormitories. Oklahoma County has a population of approximately 629,000. The populations of Oklahoma City, Midwest City, and Del City, which border Tinker AFB, are approximately 407,000, 58,000, and 33,000, respectively.

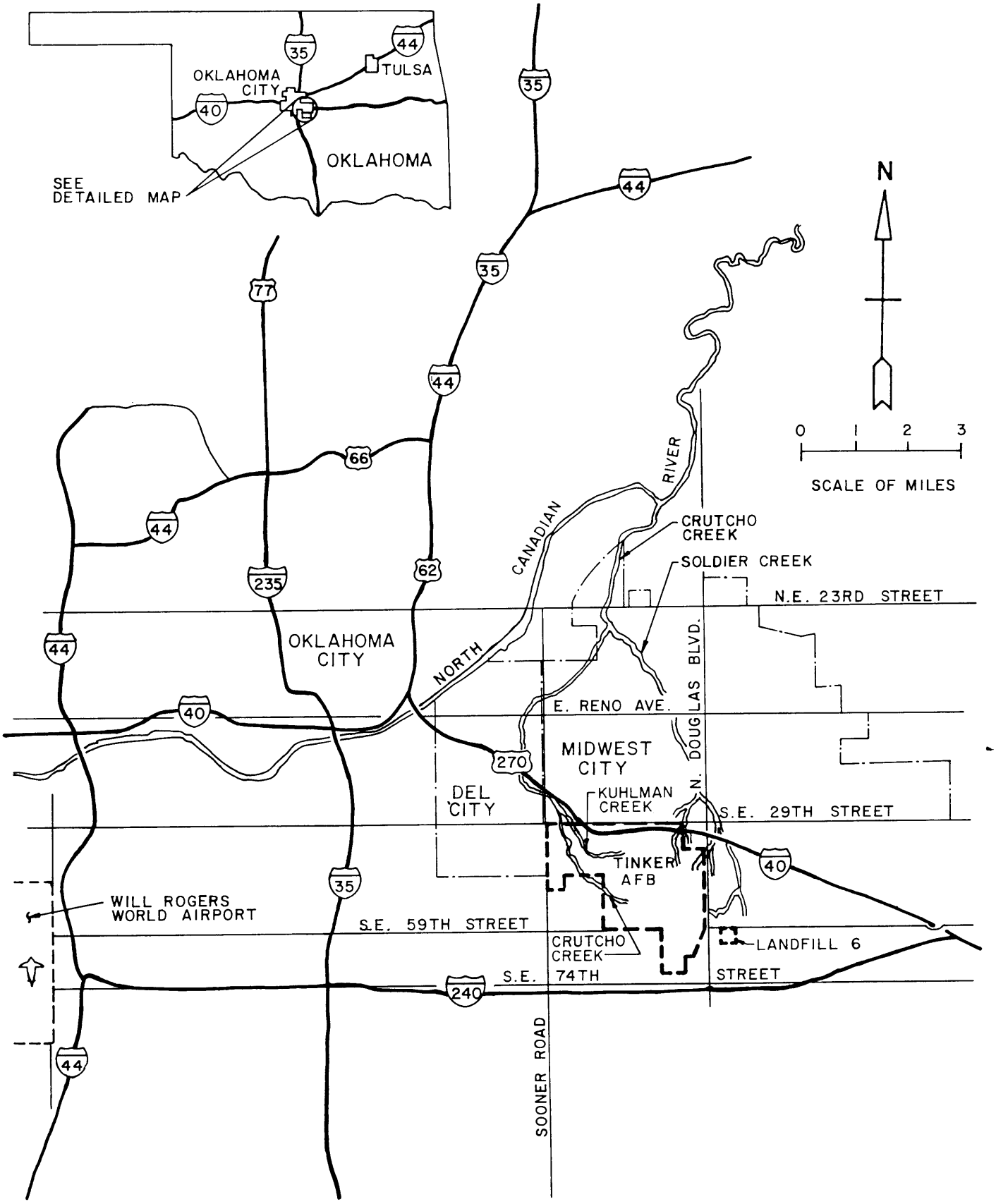

FIGURE 1-1
SITE VICINITY
TINKER AFB-SOLDIER CREEK OPERABLE UNIT
RECORD OF DECISION

CAD DWG NO: C0002745
DATE: 7-30-93 KVV
PLOT SCALE: 1=1

EAST RENO AVE
MIDWEST CITY
ATCHISON TOPEKA AND SANTA FE
15TH
AIR DEPOT BLVD
MIDWEST BLVD
I-40
29TH
REGIONAL PARK
GOLF COURSE
GOLF COURSE
GOLF COURSE
DOUGLAS BLVD
PARK
TRIBUTARY "C"
SOLDIER CREEK
SCHOOL
SOLDIER CREEK BAPTIST CHURCH
"M3" SEGMENT
MOTEL
"W2" SEGMENT
"M2" SEGMENT
MAIN SOLDIER CREEK
CAR DEALERSHIP MAINTENANCE
METAL PLATING FACILITY
TRAILER PARK
TINKER MOTEL
WEST SOLDIER CREEK
SERVICE STATION
DRY CLEANERS
TRAILER PARK
SALVAGE YARD
TRAILER PARK
"E2" SEGMENT
"W1" SEGMENT
FORMER PAINT SHOP
FORMER VACANT LOT
TRAILER PARK
I-40
"M1" SEGMENT
TINKER AIR FORCE BASE
OUTFALL A
OUTFALL B
OUTFALL C
NORTH TANK AREA
SERVICE STATION
IWTP
"E1" SEGMENT
OUTFALL F
REPAIR SHOP
"B" SEGMENT
TRIBUTARY "D"
OUTFALL D
OUTFALL L
OUTFALL M
OUTFALL E
3001
OUTFALL G
TRIBUTARY "B"
44TH
OUTFALL I
3705
EAST SOLDIER CREEK
SOUTHWEST TANK AREA
OUTFALL H
OUTFALL J
COMMERCIAL SANITARY LANDFILL
"A" SEGMENT
BERRYMAN
TRIBUTARY "A"
59TH
LANDFILL 6
CSC
DOUGLAS BLVD
I-240
I-240

LEGEND

SOLDIER CREEK AND TRIBUTARIES

UNDERGROUND PORTION OF CREEK

BOUNDARY OF TINKER AIR FORCE BASE

N

2000' 1000' 0 2000' 4000'

1"=2000'

FIGURE 1-2
SITE LOCATION
TINKER AFB - SOLDIER CREEK OPERABLE UNIT
RECORD OF DECISION

Soldier Creek and its branches are bordered mainly by recreational and residential areas with some areas supporting commercial and industrial uses. The areas east of the Base are primarily used for agriculture. On-base areas of the Soldier Creek Sediment and Surface Water Operable Unit are adjacent to the eastern-most runway area, the Building 3001 complex, and the Industrial Wastewater Treatment Plant (IWTP). Off-base portions of the Soldier Creek Sediment and Surface Water Operable Unit are in the 100-year floodplain, but the floodplain is limited in extent. The on-base portions of East and West Soldier Creeks are not included in the 100-year floodplain.

1.3 Climatology

The climate at Tinker AFB is typically characterized by long, dry, hot summers. The average annual temperature is approximately 60 to 62 degrees Fahrenheit. The highest average monthly precipitation occurs in May. Precipitation decreases in June, setting the stage for hot, dry summers. June, July, and August are the hottest months of the year. Precipitation is also high in autumn, but tapers off with January being a dry month. The average annual precipitation for Tinker AFB is approximately 40 inches. The average annual precipitation for the entire Oklahoma City area is approximately 32 inches. The prevailing wind direction is from the south-southeast.

1.4 Water Resources

Soldier Creek is classified by the State of Oklahoma as an unlisted surface water. The State of Oklahoma designates unlisted surface waters as suitable for agriculture, industrial and municipal process and cooling water, secondary body-contact recreation, limited fishery, and aesthetics. Soldier Creek is primarily used for aesthetics and limited recreation.

The Soldier Creek Sediment and Surface Water Operable Unit lies within the limits of the Garber-Wellington Groundwater Aquifer Basin, also known as the Central Oklahoma Aquifer. Regionally, the Garber-Wellington is the single, most important source of potable groundwater in the Oklahoma City metropolitan area; however, it is not considered a sole source aquifer. The four aquifer zones present in the area of the operable unit from shallowest to deepest are the perched aquifer where present, the top of regional aquifer zone, the regional aquifer zone, and the producing zone. The perched aquifer is not a source of drinking water. The top of regional and regional aquifer zones may be potential sources of drinking water. The producing zone is a source of drinking water for the area. The top of regional, the regional, and the producing aquifer zones are part of the Garber-Wellington aquifer. A comprehensive discussion of the regional and site-specific geology and hydrogeology is presented in the RI report, which is available in the Administrative Record file.

2.0 SITE HISTORY

This section of the ROD presents a summary of the site history, including previous and current investigations, remedial activities conducted at the operable unit, and enforcement activities.

Tinker AFB is a major industrial complex for overhauling, modifying, and repairing military aircraft, aircraft engines, and accessory items. Industrial operations at the Base began in 1942.

2.1 Previous Investigations and Remedial Activities

As part of the overall Air Force Installation Restoration Program, Tinker AFB began environmental investigations of previously used waste disposal sites in 1981. A basewide sampling program was conducted in 1983. Because of the presence of trichloroethene and chromium in the groundwater, portions of Tinker AFB were added to the National Priorities List (NPL) on July 22, 1987. The site was divided into three operable units, Building 3001, which includes the groundwater below Building 3001, the North Tank Area, Pit Q-51, and Water Wells 18 and 19; Soldier Creek sediment and surface water; and Soldier Creek groundwater. As previously stated, this ROD addresses the Soldier Creek Sediment and Surface Water Operable Unit.

Numerous activities have been conducted to identify and eliminate potential sources of contamination to Soldier Creek. In 1986, excavation activities were conducted along East and West Soldier Creeks. Approximately 7,500 cubic yards of contaminated sediment were removed. In addition, more than 14 underground storage tanks and solvent pits were excavated and removed or filled and abandoned in place in the vicinity of Soldier Creek over the last three years.

In 1989, a survey to identify possible old industrial waste cross-connections in the Building 3001 area was performed. Based on this study, in 1990 and 1991, several industrial cross-connections that may have been contaminating the Soldier Creek storm-water system with industrial wastes were identified and eliminated.

In 1990, a complete overhaul of the Plating Shop Facility inside Building 3001 was initiated. This overhaul included replacing all of the process equipment and coating the basement floor with a material resistant to chromic acid, which is used in the Plating Shop operations. By replacing potentially leaking equipment and preventing contaminants from entering the concrete and soil in the area, chromium and other contaminants used in the Plating Shop operations may be prevented from reaching the groundwater and West Soldier Creek.

Since Tinker AFB was added to the NPL, a remedial investigation/feasibility study (RI/FS) of the Soldier Creek Sediment and Surface Water Operable Unit has been conducted. Fieldwork was conducted in July 1990 (Phase I) and June 1991 (Phase II). The results of the RI, the baseline risk assessment, and the FS conducted for the Soldier Creek Sediment and Surface Water Operable Unit are summarized in subsequent sections of this ROD. Table 2-1 (page 2-3) presents a brief summary of previous activities conducted at Tinker AFB under the Installation Restoration Program at or in the vicinity of Soldier Creek.

2.2 Current Remedial Activities

Remedial activities are currently underway at the Building 3001 Operable Unit at Tinker AFB. This operable unit comprises the groundwater contamination that underlies Building 3001 itself and West Soldier Creek, the North Tank area, Pit Q-51, and Water Wells 18 and 19. The Building 3001 ROD was signed on August 16, 1990. The remedy selected for the remediation of the contaminated groundwater includes extraction and treatment. The groundwater treatment process uses chemical precipitation and air stripping to remove inorganic and organic contaminants, respectively, from extracted groundwater. Performance testing is ongoing, and trial operation has begun. The treated water is to be reused at the Base in its industrial operations. Remedies also included removing and disposing of contaminated pit contents at Q-51, and removing and disposing of contaminated subsurface soil in the North Tank Area. Water Wells 18 and 19 were plugged in 1986.

2.3 Enforcement Activities

On December 9, 1988, the U.S. Environmental Protection Agency (EPA) Region 6, the Oklahoma State Department of Health (OSDH), and the U.S. Department of the Air Force, Tinker AFB signed an FFA (Administrative Docket Number NPL-U3-2-27) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Section 120 as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The intent of this agreement is to ensure that the past and present activities at the Tinker AFB NPL Site are thoroughly investigated and appropriately remediated to protect the public health, welfare, and environment. The FFA establishes requirements for the performance of RI/FSs at the operable units in accordance with CERCLA. In addition, the FFA establishes procedures and schedules for developing, implementing, monitoring, documenting, and approving response actions at both the Building 3001 and Soldier Creek Sediment and Surface Water Operable Units, in accordance with CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and Superfund guidance and policy. The agreement sets procedures for remedial actions and specifies that Tinker AFB will establish and maintain an

TABLE 2–1
SUMMARY OF PREVIOUS INVESTIGATIONS AND ACTIVITIES
TINKER AFB – SOLDIER CREEK
RECORD OF DECISION

INVESTIGATION/ACTIVITY	INVESTIGATOR	DATES	PURPOSE
Installation Restoration Program Phase II Confirmation/ Quantification Stage 2 Investigation	Radian Corporation	6/84 – 7/84	Determine if solvent storage and waste disposal resulted in environmental contamination at Tinker AFB.
Sediment and Surface Water Sampling	EPA	10/84, 11/84	Evaluate the effects of wastewater discharge from Tinker AFB on water quality of Crutcho and Soldier Creeks.
Sediment Sampling and Dredging	Harry Keith & Sons, Inc.	10/85 4/86 & 5/86	Evaluate magnitude of contamination in East and West Soldier Creeks. Dredging of unknown volume of sediment from on–base portions of East and West Soldier Creeks.
North Tank Area	Tinker AFB	1985–Present	Remove fuel contamination in the groundwater north of Building 3001.
Water Wells 18 and 19	Tinker AFB	1986	Plugged and abandoned contaminated water wells inside of Building 3001.
Surface Water Sampling	Tinker AFB	3/87 – 9/87	Sample IWTP and Sanitary Treatment Plant surface water discharges.
Sediment and Surface Water Sampling	Oklahoma State Department of Health	6/87	Sample sediment and surface water from East Soldier Creek.
NPDES Surface Water Sampling	Tinker AFB	9/86 – 7/87	Determine surface water concentrations downstream of IWTP effluent discharge location.
Building 3001 Remedial Investigation	Tulsa COE	5/86 – 4/87 1/88 – 6/89	Determine groundwater contamination in the area of Building 3001 and the IWTP.
Quarterly Groundwater Sampling	Tulsa COE	12/87 – 3/89 3/88, 10/88	Sample groundwater in the area of Building 3001, the IWTP, and East and West Soldier Creeks.
Final Storm Sewer Investigation For Soldier Creek	NUS Corporation	10/89	Sample surface water to identify contaminant release from Building 3001 storm sewers to East and West Soldier Creeks.
Industrial Wastewater Treatment Plant Remedial Investigation	Tulsa COE	3/88 – 9/90	Sample groundwater in the vicinity of the IWTP to assess groundwater contamination beneath the IWTP.
Soldier Creek Remedial Investigation, Phase I and II	B&V Waste Science and Technology Corp.	July 1990 June 1991	Determine the extent of sediment and surface water contamination along East, Main, and West Soldier Creeks.
Pit Q–51	Tinker AFB	1991	Cleaned and abandoned old solvent pit inside of Building 3001.
Remedial Design of Building 3001 Groundwater Treatment System	B&V Waste Science and Technology Corp.	1991	Design of treatment system to remediate groundwater contamination associated with the Building 3001 Operable Unit that underlies West Soldier Creek.
Construction of Building 3001 Groundwater Treatment System	B&V Waste Science and Technology Corp.	1992	Construction of treatment system to remediate groundwater contamination associated with the Building 3001 Operable Unit that underlies West Soldier Creek. Startup of treatment system estimated to be in 1993.

Administrative Record that will include all documents that form the basis for the selection of a response action at both the Building 3001 and Soldier Creek Sediment and Surface Water Operable Units at the Tinker AFB Site. An Administrative Record for the Soldier Creek Groundwater Operable Unit at Tinker AFB will also be established.

3.0 COMMUNITY PARTICIPATION

The Administrative Record and the Proposed Plan for the Soldier Creek Operable Unit were released to the public for comment in April 1993. The RI, FS, Risk Assessment, Environmental Assessment, and FS Initial Screening of Alternatives reports, and the Proposed Plan are contained in the Administrative Record file and are available to the public at four locations: the Midwest City Public Library, Tinker AFB, the OSDH offices in Oklahoma City, Oklahoma, and the EPA Region 6 offices in Dallas, Texas. The notice of availability of these documents was published in a newspaper announcement on April 16, 1993.

Tinker AFB solicited input from the community on the proposed remedy for this operable unit. A public comment period was held from April 16, 1993, to June 17, 1993, to encourage public participation in the remedial process. Both the public comment period and the public meeting were initially announced to the public in the *Daily Oklahoman*, a large local newspaper of general circulation on April 16, 1993. A fact sheet was prepared and sent to individuals on the mailing list on April 23, 1993. The public meeting was held in Midwest City on April 27, 1993. At this meeting, representatives of Tinker AFB presented information and answered questions about the Soldier Creek Sediment and Surface Water Operable Unit and the remedial alternatives under consideration. Representatives of the EPA and OSDH were present at the meeting. Tinker AFB provided notice of the public meeting through a newspaper announcement on April 26, 1993, and a press conference held on April 26, 1993. During this meeting, the public comment period was extended for 30 days. A public notice was placed in the community section of the *Daily Oklahoman* for three days notifying the public of this extension. On May 17, 1993, the Base newspaper also ran a story detailing cleanup alternatives and the extension date. A transcript of the public meeting is available in the Administrative Record file. Responses to the comments received during the public comment period are included in the Responsiveness Summary in Appendix A of this ROD. The decision for this operable unit is based on the information contained in the Administrative Record file.

4.0 SCOPE AND ROLE OF OPERABLE UNIT

The Tinker AFB NPL Site comprises three operable units:

- Building 3001, which includes the groundwater below Building 3001, the North Tank Area, Pit Q-51, and Water Wells 18 and 19.
- Soldier Creek Sediment and Surface Water.
- Soldier Creek Groundwater.

Remedies for the Building 3001 Operable Unit have already been selected. Contaminated groundwater is the principle threat at this operable unit. The remedy includes the extraction and treatment of groundwater below Building 3001. As discussed in Section 2.2 of this ROD, treatment system trial operations have begun. The remedies also included removing and disposing of contaminated pit contents from Pit Q-51, and removing and disposing of fuel products in the subsurface soil at the North Tank Area. Water Wells 18 and 19 were plugged in September 1986.

This ROD addresses the Soldier Creek Sediment and Surface Water Operable Unit. The purpose of this response action is to address the risks to the public and the environment from direct contact with Soldier Creek sediment and surface water and the threat of migration of contaminants from the stream to the groundwater below Soldier Creek. The overall objective is to prevent exposure to and migration of contaminants with concentrations greater than the final remediation goals. These goals are based on the baseline risk assessment conducted for the operable unit and are presented in Section 6.0 of the ROD.

The groundwater associated with Soldier Creek was investigated during the RI for the Soldier Creek Sediment and Surface Water Operable Unit. However, because of the complexity of potential groundwater interactions between the operable units at Tinker AFB and because not enough data have been collected to determine the nature of the vertical and horizontal extent of contamination, the groundwater associated with Soldier Creek is to be addressed as a separate operable unit under CERCLA and the FFA.

5.0 SITE CHARACTERISTICS

This section provides a summary of the nature and extent of sediment and surface water contamination at the Soldier Creek Sediment and Surface Water Operable Unit. This summary is based on the data generated by the work performed pursuant to the RI/FS. A comprehensive discussion of the operable unit characteristics is presented in the RI report.

5.1 Sources of Contamination

Several possible past sources of contamination to Soldier Creek from Tinker AFB have been identified. These may have been indirect sources of chemicals to Soldier Creek through surface water runoff or from possible perched aquifer zone groundwater discharge to the creek. These past sources include Building 3001, underground storage tanks in the north and southwest tank areas, abandoned solvent pits, and a storm drain outfall south of the IWTP. However, as discussed in Section 2.1, these sources have been eliminated through remedial activities implemented at the Base. The approximate locations of these former possible sources are shown on Figure 1-2 (page 1-3).

A total of 12 industrial outfalls and storm drains are known to have discharged directly to East and West Soldier Creeks on the Base. All of the cross-connections between the outfalls and the industrial waste lines were closed by 1990. The storm drains are still active. All industrial waste is now transported to the IWTP through underground lines. Off-base industrial outfalls and storm drains, located downstream on East and West Soldier Creeks and upstream and downstream along the main stream, discharge flows into Soldier Creek and its tributaries. These possible past on-base and current off-base point sources could have discharged hazardous substances and other contaminants directly into the creeks.

Accidental spills of chemical substances may have occurred at on-base or off-base locations within the Soldier Creek drainage system. Such spills may have resulted in contaminant transport to Soldier Creek by surface runoff or to underlying groundwater by leaching and percolation from the soil.

Several potential off-base contamination sources may exist, including but not limited to underground gasoline storage tanks associated with service stations, a salvage yard, an auto repair shop, a paint shop, a vacant lot north of Tinker AFB that contains dumped materials, and other industrial service and manufacturing facilities in the vicinity of Soldier Creek. The paint shop and vacant lot are no longer considered off-base because Tinker AFB purchased the property that was formerly the site of these potential sources in 1992. These potential sources are shown on Figure 1-2 (page 1-3).

5.2 Location and Extent of Sediment Contamination

The extent of sediment contamination in Soldier Creek was assessed by collecting hand-augered samples to a depth of 5 feet below the stream bed. Fourteen volatile organics, 29 semi-volatile organics, and 20 inorganics were detected in sediment samples collected from Soldier Creek and its tributaries. The sample locations for both phases of the RI are shown on Figure 5-1 (page 5-3).

Table 5-1 (pages 5-4 and 5-5) presents the volatile organics, semi-volatile organics, and inorganics detected in Soldier Creek sediment during each phase of the RI. The table also presents the frequency of detection, the concentration range detected, and the background concentrations. Background sediment sampling locations were selected so as not to be influenced by potential sources of contamination; therefore, the background sample locations were sited on private property along east tributaries of Soldier Creek. The following subsections summarize the extent of contamination in the sediment.

5.2.1 Volatile Organic Contamination

Methylene chloride, acetone, chloroform, tetrachloroethene, toluene, and xylene (total) were the most frequently detected compounds. Chloroethane, 1,2-dichloroethene, ethylbenzene, and trichlorothene were detected at only on-base sample locations. Vinyl acetate and benzene were detected at only off-base sample locations. Compared to all volatile organics detected during Phase I of the RI, the contaminants detected at the highest concentrations during Phase I of the RI were methylene chloride and 1,2-dichloroethene. Compared to all volatile organics detected during Phase II of the RI, the contaminants detected at the highest concentrations during Phase II of the RI were methylene chloride and acetone. Acetone, chloroform, methylene chloride, tetrachloroethene, toluene, and xylene (total) were detected at background sample locations. Several compounds detected during Phase I of the RI [1,2-dichloroethene (total), trichloroethene, chloroethane, ethylbenzene, and vinyl acetate] were not detected during Phase II of the RI. Benzene was only detected during Phase II of the RI. In general, there appeared to be higher volatile organic concentrations on-base and at depths greater than 6 inches. Building 3001 outfalls have been identified as past sources of chloroform, chloroethane, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, benzene, toluene, and xylene (total) contamination. Building 3001 is no longer a source of contamination to Soldier Creek because the industrial cross-connections were removed. While the off-base locations where contaminants were detected are downstream of the Building 3001 outfalls, these locations range from one half to one mile downstream of the Building 3001 outfalls and receive surface runoff from numerous off-base potential sources of contamination. The overall concentration of volatile organics detected in the sediment was higher in Phase I than Phase II of the RI. The lower concentrations detected during Phase II of the RI may be the result of natural attenuation, degradation, or migration of the contaminants.

CAD DRG NO: C0002813
DATE: 8-2-9 KVV
PLOT SCALE 1

EAST RENO AVE
MIDWEST CITY
ATCHISON TOPEKA AND SANTA FE
15TH
29TH
I-40
I-240
T120
DOUGLAS BLVD
BERRYMAN
GOLF COURSE
REGIONAL PARK
PARK
SOLDIER CREEK SCHOOL
SOLDIER CREEK BAPTIST CHURCH
MOTEL
CAR DEALERSHIP MAINTENANCE
METAL PLATING FACILITY
TINKER MOTEL
TRAILER PARK
SERVICE STATION
DRY CLEANERS
SALVAGE YARD
FORMER PAINT SHOP
FORMER VACANT LOT
NORTH TANK AREA
SOUTHWEST TANK AREA
IWTP
REPAIR SHOP
COMMERCIAL SANITARY LANDFILL
LANDFILL 6
CSC
TINKER AIR FORCE BASE
WEST SOLDIER CREEK
MAIN SOLDIER CREEK
TRIBUTARY "B"
EAST SOLDIER CREEK
TRIBUTARY "A"
OUTFALL A
OUTFALL B
OUTFALL C
OUTFALL D
OUTFALL E
OUTFALL F
OUTFALL G
OUTFALL H
OUTFALL I
OUTFALL J
OUTFALL K
OUTFALL M
3001
3705
M13 M12 M11 M10 M09 M08 M07 M06 M05 M04 M03 M02 M01
W09 W08 W07 W06 W05 W04 W03 W02 W01
E13 E12 E11 E10 E09 E08 E07 E06 E05 E04 E03 F02 E01
B03 B02 B01
A03 A02 A01
C03 C02 C01
D01
44TH
59TH

LEGEND

- SOLDIER CREEK AND TRIBUTARIES
- UNDERGROUND PORTION OF CREEK
- BOUNDARY OF TINKER AIR FORCE BASE
- M11 ◑ PHASE I SAMPLING LOCATION ONLY
- C02 ⊗ PHASE II SAMPLING LOCATION ONLY
- M10 ● PHASE I AND II SAMPLING LOCATION

N

2000' 1000' 0 2000' 4000'

1"=2000'

FIGURE 5-1
PHASE I AND II SAMPLING LOCATIONS
TINKER AFB - SOLDIER CREEK OPERABLE UNIT
RECORD OF DECISION

TABLE 5-1
CONTAMINANTS DETECTED IN SOLDIER CREEK SEDIMENT
TINKER AFB – SOLDIER CREEK
RECORD OF DECISION

CHEMICAL	RI PHASE	FREQUENCY OF DETECTION (1)	RANGE OF SAMPLE QUANTITATION LIMITS (2) (ug/kg)(3)	RANGE OF DETECTED CONCENTRATIONS (ug/kg)(3)	BACKGROUND LEVELS (ug/kg)(3)
Acetone	Phase I	32/41	2.0 to 10.0	ND to 1,700.0	ND to 9.0
	Phase II	13/17	10.0 to 12.0	ND to 51.0	ND to 51.0
Benzene	Phase I	0/41	ND	ND	ND
	Phase II	1/17	1.0 to 6.0	ND to 1.0	ND
Carbon Disulfide	Phase I	1/41	6.0 to 10.0	ND to 36.0	ND
	Phase II	2/17	0.9 to 6.0	ND to 2.0	ND
Chlorobenzene	Phase I	4/41	6.0 to 10.0	ND to 78,000.0	ND
	Phase II	1/17	6.0	ND to 10.0	ND
Chloroethane	Phase I	1/41	12.0	ND to 86.0	ND
	Phase II	0/17	ND	ND	ND
Chloroform	Phase I	41/41	1.0 to 10.0	ND to 9,200.0	5.0
	Phase II	5/17	0.6 to 6.0	ND to 2.0	ND to 2.0
1,2-Dichloroethene (Total)	Phase I	2/41	6.0 to 10.0	ND to 180,000.0	ND
	Phase II	0/17	ND	ND	ND
Ethylbenzene	Phase I	1/41	3.0 to 10.0	ND to 4.0	ND
	Phase II	0/17	ND	ND	ND
Methylene Chloride	Phase I	41/41	1.0 to 10.0	ND to 140,000.0	9.0 to 10.0
	Phase II	12/17	1.0 to 6.0	ND to 51.0	ND to 30.0
Tetrachloroethene	Phase I	2/41	1.0 to 10.0	ND to 83,000.0	ND
	Phase II	5/17	2.0 to 6.0	ND to 11.0	ND to 11.0
Toluene	Phase I	12/41	1.0 to 10.0	ND to 980.0	ND
	Phase II	4/17	0.9 to 6.0	ND to 6.0	ND to 6.0
Trichloroethene	Phase I	1/41	6.0 to 10.0	ND to 4,100.0	ND
	Phase II	0/17	ND	ND	ND
Vinyl Acetate	Phase I	1/41	0.9 to 10.0	ND to 0.9	ND
	Phase II	0/17	ND	ND	ND
Xylene (Total)	Phase I	3/41	4.0 to 10.0	ND to 1,000.0	ND
	Phase II	7/17	0.7 to 6.0	ND to 6.0	ND to 6.0
Acenaphthene	Phase I	12/41	17.0 to 3,300.0	ND to 1,100.0	ND
Anthracene	Phase I	17/41	10.0 to 3,300.0	ND to 1,500.0	ND
Benzo(A)anthracene	Phase I	19/41	38.0 to 3,300.0	ND to 4,800.0	ND
Benzo(B)fluoranthene	Phase I	17/41	39.0 to 3,300.0	ND to 9,200.0	ND
Benzo(K)fluoranthene	Phase I	14/41	41.0 to 3,300.0	ND to 5,300.0	ND
Benzo(G,H,I)perylene	Phase I	11/41	120.0 to 3,300.0	ND to 4,100.0	ND
Benzo(A)pyrene	Phase I	18/41	27.0 to 3,300.0	ND to 4,400.0	ND
Bis(2-ethylhexyl)phthalate	Phase I	41/41	60.0 to 3,300.0	ND to 46,000.0	ND
Butylbenzylphthalate	Phase I	5/41	29.0 to 3,300.0	ND to 720.0	ND
2-Chloronaphthalene	Phase I	4/41	220.0 to 3,300.0	ND to 1,600.0	ND
Chrysene	Phase I	20/41	63.0 to 3,300.0	ND to 7,100.0	ND
Dibenz(A,H)anthracene	Phase I	2/41	48.0 to 3,300.0	ND to 110.0	ND
Dibenzofuran	Phase I	7/41	35.0 to 3,300.0	ND to 480.0	ND
1,2-Dichlorobenzene	Phase I	4/41	30.0 to 3,300.0	ND to 3,100.0	ND
1,3-Dichlorobenzene	Phase I	4/41	31.0 to 3,300.0	ND to 280.0	ND

TABLE 5-1 (Continued)
CONTAMINANTS DETECTED IN SOLDIER CREEK SEDIMENT
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

CHEMICAL	RI PHASE	FREQUENCY OF DETECTION (1)	RANGE OF SAMPLE QUANTITATION LIMITS (2) (ug/kg)(3)	RANGE OF DETECTED CONCENTRATIONS (ug/kg)(3)	BACKGROUND LEVELS (ug/kg)(3)
1,4-Dichlorobenzene	Phase I	5/41	52.0 to 3,300.0	ND to 4,400.0	ND
3,3-Dichlorobenzidine	Phase I	1/41	1,600.00 to 3,300.0	ND to 1,700.0	ND
2,4-Dimethylphenol	Phase I	1/41	160.0 to 3,300.0	ND to 160.0	ND
Di-n-butylphthalate	Phase I	20/41	11.0 to 3,300.0	ND to 2,200.0	ND
Di-n-octylphthalate	Phase I	16/41	14.0 to 3,300.0	ND to 540.0	ND
Fluoranthene	Phase I	24/41	3.0 to 3,300.0	ND to 11,000.0	ND
Fluorene	Phase I	9/41	57.0 to 3,300.0	ND to 880.0	ND
Indeno(1,2,3-CD)pyrene	Phase I	11/41	100.0 to 3,300.0	ND to 3,800.0	ND
2-Methylnaphthalene	Phase I	10/41	14.0 to 3,300.0	ND to 1,900.0	ND
2-Methylphenol	Phase I	1/41	68.0 to 3,300.0	ND to 68.0	ND
4-Methylphenol	Phase I	1/41	98.0 to 3,300.0	ND to 98.0	ND
Naphthalene	Phase I	11/41	44.0 to 3,300.0	ND to 690.0	ND
Phenanthrene	Phase I	20/41	9.0 to 3,300.0	ND to 6,700.0	ND
Pyrene	Phase I	21/41	18.0 to 3,300.0	ND to 10,000.0	ND
Aluminum	Phase I	41/41	423.0 to 20,000.0	423.0 to 42,300.0	4,050.0 to 4,060.0
Arsenic	Phase I	39/41	0.97 to 1,000.0	ND to 15.7	1.6
Barium	Phase I	41/41	3.2 to 20,000.0	63.0 to 2,910.0	64.4 to 76.2
Cadmium	Phase I	31/41	0.55 to 500.0	ND to 428.0	ND
	Phase II	15/17	0.9 to 500.0	ND to 15.7	ND to 2.08
Calcium	Phase I	41/41	348.0 to 500,000.0	653.0 to 72,500.0	775.0 to 4,070.0
Chromium	Phase I	41/41	2.40 to 1,000.0	4.9 to 2,020.0	8.0 to 8.4
	Phase II	17/17	4.6 to 1,000.0	ND to 186.0	ND to 9.6
Cobalt	Phase I	41/41	1.8 to 5,000.0	ND to 52.1	2.5 to 3.1
Copper	Phase I	40/41	4.8 to 2,500.0	ND to 600.0	14.8 to 36.6
Cyanide	Phase I	2/41	2.30 to 1,000.0	ND to 6.5	ND
	Phase II	0/17	2.30	ND	ND
Iron	Phase I	41/41	827.0 to 10,000.0	827.0 to 41,200.0	5,780.0 to 10,700.0
Lead	Phase I	41/41	2.2 to 300.0	2.2 to 586.0	6.7 to 7.7
	Phase II	17/17	4.0 to 300.0	ND to 152.0	ND to 54.3
Magnesium	Phase I	41/41	83.6 to 500,000.0	179.0 to 20,400.0	734.0 to 1,160.0
Manganese	Phase I	41/41	4.2 to 1,500.0	8.8 to 1,490.0	56.4 to 100.0
Mercury	Phase I	13/41	0.12 to 100.0	ND to 2.6	ND
Nickel	Phase I	41/41	2.8 to 4,000.0	2.8 to 2,270.0	8.0 to 8.6
Potassium	Phase I	41/41	99.3 to 500,000.0	ND to 2,300.0	495.0 to 552.0
Selenium	Phase I	14/41	0.56 to 500.0	ND to 10.2	ND
Silver	Phase I	27/41	0.49 to 1,000.0	ND to 112.0	0.53 to 0.91
Vanadium	Phase I	41/41	1.4 to 5,000.0	1.4 to 52.9	8.8 to 9.4
Zinc	Phase I	41/41	3.50 to 2,000.0	3.5 to 640.0	10.2 to 13.9

Legend:
ND-Not Detected

Note:
(1) Number of samples in which the chemical was positively detected over the number of samples available.
(2) The maximum limit is the contract required quantitation limit.
(3) The units of concentration for inorganic constituents are mg/kg.

5.2.2 Semi-Volatile Organic Contamination

Di-n-butylphthalate, fluoranthene, bis-(2-ethylhexyl)phthalate, and di-n-octyl-phthalate were the most frequently detected semi-volatile organic compounds. Most of the semi-volatile contaminants detected were found on-base, immediately off-base, or in stream segments upstream of the Base. However, the maximum concentrations detected were all on-base and downstream of Outfall G, which is known to have discharged semi-volatile organics to East Soldier Creek in the past. The source of this contamination in Outfall G was probably Building 3001; however, this source was eliminated when the industrial cross-connections were removed. The maximum concentrations were detected primarily in the 0 to 6-inch sampling interval. The location of Outfall G is shown on Figure 1-2 (page 1-3). Samples for semi-volatile analysis were primarily collected during Phase I of the RI. Only one sample for semi-volatile analysis was collected during Phase II of the RI. However, no semi-volatile organics were detected in the sample. Three samples were collected along Outfall G in September 1992. One type of polychlorinated biphenyl (PCB-1254) was detected at all three sampling locations. No other PCBs were detected. The concentrations of the PCB detected were 9.3 parts per million (ppm) at the upstream sampling location, 1.9 ppm at the middle location, and 0.5 ppm at the downstream sample location. PCBs were not analyzed for during the RI because historical data indicated that PCBs were not present along on-base portions of East Soldier Creek at significant concentrations (less than one part per billion). It is possible that the source of the PCB contamination is from the Outfall G discharge. Although there are no known industrial processes within Building 3001 that use PCBs, old electrical transformers were known to have oil that contained PCBs. All transformers with PCB-containing oil were replaced in 1989; however, it is possible that before this time a minor spill of transformer oil containing PCBs could have occurred and entered the storm drain system.

5.2.3 Inorganic Contamination

Many inorganics were detected at on-base and off-base sample locations; however, the maximum concentrations detected were generally found on-base. The maximum concentrations were detected primarily in the shallow sediment sampling intervals (0 to 2 feet). Cadmium and chromium were detected above background concentrations at on-base and off-base locations within East, Main, and West Soldier Creeks. All of the inorganics shown in Table 5-1 (pages 5-4 and 5-5) were analyzed during Phase I of the RI; however, cadmium, chromium, cyanide, and lead were the only inorganic analytes analyzed during Phase II of the RI based on the results of a preliminary risk assessment performed after completion of Phase I of the RI. Sources of inorganic contaminants in Soldier Creek may include Building 3001 and off-base sources. These potential off-base sources include underground gasoline storage tanks containing leaded fuel, salvage yards, paint shops using leaded paint, and other facilities associated with auto repair and metal plating. Many of the inorganics may also be naturally occurring analytes in the sediment. Table 5-2 (page 5-7) presents

TABLE 5-2
TYPICAL BACKGROUND SOIL CONCENTRATIONS
TINKER AFB-SOLDIER CREEK
RECORD OF DECISION

Constituent	Native U.S. Surface Soil Concentration (ppm)(1)	Oklahoma Surface Soil Concentration (ppm)(2)	Soldier Creek Background Concentration (ppm)
Aluminum	50,000	10,000-300,000	4,050-4,060
Arsenic	6.5	1.0-40	1.6
Barium	500	100-3,500	64.4-76.2
Cadmium	NA	0.01-7.0	ND-2.08
Calcium	3,500-7,900	100,000-400,000	775-4,070
Chromium	1.0-70	5.0-3,000	8.0-9.6
Cobalt	7	1.0-40	2.5-3.1
Copper	15	2.0-100	14.8-36.6
Cyanide	NA	NA	ND
Iron	1.5	7,000-550,000	5,780-10,700
Lead	<10-15	2.0-200	6.7-54.3
Magnesium	5,000-7,000	600-6,000	734-1,160
Manganese	200-300	100-4,000	56.4-100
Mercury	0.032	0.01-0.08	ND
Nickel	10-20	5.0-1,000	8.0-8.6
Potassium	1.6	400-30,000	495-552
Selenium	0.3	0.1-2.0	ND
Silver	NA	0.1-5.0	0.53-0.91
Vanadium	70	20-500	8.8-9.4
Zinc	<5.0-17	10-300	10.2-13.9

Legend:
NA-Not Available
ND-Not Detected

Notes:
(1) Shacklette, Hansford T., and Josephine G. Boerngen, "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States," U.S. Geological Survey Professional Paper 1270, 1984.

(2) Dragun, James, Ph.D, "The Soil Chemistry of Hazardous Materials," Hazardous Materials Control Research Institute, Silver Spring, Maryland, 1988.

typical background soil concentrations for inorganic analytes detected in Soldier Creek sediment. The table shows that the analytes occur in surface materials. In general, the metals were detected in samples from the same stream segments during both phases of the RI. A more complete analysis of the chemical results can be found in the RI report.

5.3 Location and Extent of Surface Water Contamination

The extent of surface water contamination was determined during the RI by collecting samples at the same locations as the sediment samples. Fifteen volatile organics, 5 semi-volatile organics, and 21 inorganics were detected in surface water samples collected from Soldier Creek and its tributaries.

Table 5-3 (pages 5-9 and 5-10) presents the volatile organics, semi-volatile organics, and inorganics detected in Soldier Creek surface water during each phase of the RI. The table also presents the frequency of detection, the concentration range detected, and the background concentrations. The following subsections summarize the extent of contamination in the surface water.

5.3.1 Volatile Organic Contamination

Methylene chloride, acetone, chloroform, and 1,1,1-trichloroethane were the most frequently detected volatile organic compounds. 1,2-Dichloroethene was only detected at on-base sample locations. Benzene, chlorobenzene, and xylene (total) were only detected at off-base sample locations. Bromodichloromethane, chlorobenzene, chloroform, and methylene chloride were detected at background sample locations in addition to other upstream locations. During both phases of the RI, methylene chloride was the compound detected at the highest concentration. Several compounds were detected only during Phase II of the RI [benzene, chlorobenzene, trichloroethene, carbon disulfide, and xylene (total)]. Dibromochloromethane was detected only during Phase I of the RI. There is no evidence indicating Tinker AFB has used chlorobenzene, carbon disulfide, or dibromochloromethane. Higher volatile organic concentrations were detected on-base along East Soldier Creek and downstream of outfalls that have been documented to have discharged volatiles into Soldier Creek in the past. The general trend for West Soldier Creek appears to be relatively higher volatile organic concentrations on-base than off-base. Building 3001 was eliminated as a source of contamination to Soldier Creek when the industrial cross-connections were removed.

5.3.2 Semi-Volatile Organic Contamination

Benzo(G,H,I)perylene, benzoic acid, chrysene, fluoranthene, and pyrene were detected at low concentrations at on-base sample locations, except for benzoic acid which was only detected off-base. No general trends or sources of contamination for surface water semi-volatile organic analytical results could be established.

TABLE 5-3
CONTAMINANTS DETECTED IN SOLDIER CREEK SURFACE WATER
TINKER AFB – SOLDIER CREEK
RECORD OF DECISION

CHEMICAL	RI PHASE	FREQUENCY OF DETECTION (1)	RANGE OF SAMPLE QUANTITATION LIMITS (2) (ug/L)(3)	RANGE OF DETECTED CONCENTRATIONS (ug/L)(3)	BACKGROUND LEVELS (ug/L)(3)
Acetone	Phase I	1/35	5.0 to 10.0	ND to 5.0	ND
	Phase II	6/17	4.0 to 32.0	ND to 60.0	ND
Benzene	Phase I	0/35	5.0	ND	ND
	Phase II	2/17	1.0 to 5.0	ND to 2.0	ND
Bromodichloromethane	Phase I	3/35	3.0 to 5.0	ND to 6.0	ND
	Phase II	1/17	0.9 to 5.0	ND to 0.9	ND to 0.9
Bromoform	Phase I	1/35	4.0 to 5.0	ND to 4.0	ND
	Phase II	2/17	5.0	ND to 15.0	ND
Carbon Disulfide	Phase I	0/35	5.0	ND	ND
	Phase II	4/17	0.7 to 5.0	ND to 1.0	ND
Chlorobenzene	Phase I	0/35	5.0	ND	ND
	Phase II	2/17	1.0 to 5.0	ND to 2.0	ND to 1.0
Chloroform	Phase I	15/35	0.70 to 5.0	ND to 6.0	ND
	Phase II	1/17	5.0	ND to 9.0	ND to 9.0
Dibromocholoromethane	Phase I	3/35	4.0 to 5.0	ND to 5.0	ND
	Phase II	0/17	5.0	ND	ND
1,2-Dichloroethene(Total)	Phase I	1/35	5.0	ND to 8.0	ND
	Phase II	1/17	5.0	ND to 14.0	ND
Methylene Chloride	Phase I	12/35	2.0 to 5.0	ND to 14.0	ND
	Phase II	12/17	0.8 to 5.0	ND to 620.0	ND to 0.8
Tetrachloroethene	Phase I	3/35	3.0 to 5.0	ND to 3.0	ND
	Phase II	2/17	1.0 to 5.0	ND to 6.0	ND
Toluene	Phase I	1/35	1.0 to 5.0	ND to 1.0	ND
	Phase II	4/17	4.0 to 5.0	ND to 5.0	ND
1,1,1-Trichloroethane	Phase I	1/35	2.0 to 5.0	ND to 2.0	ND
	Phase II	5/17	1.0 to 5.0	ND to 5.0	ND
Trichloroethene	Phase I	0/35	5.0	ND	ND
	Phase II	2/17	2.0 to 5.0	ND to 2.0	ND
Xylene (Total)	Phase I	0/35	5.0	ND	ND
	Phase II	1/17	2.0 to 5.0	ND to 2.0	ND
Benzo(G,H,I)perylene	Phase I	1/35	6.0 to 10.0	ND to 6.0	ND
Benzoic Acid	Phase I	2/35	0.40 to 10.0	ND to 0.4	ND
Chrysene	Phase I	1/35	5.0 to 10.0	ND to 5.0	ND
Fluoranthene	Phase I	1/35	1.0 to 10.0	ND to 1.0	ND
Pyrene	Phase I	1/35	1.0 to 10.0	ND to 1.0	ND
Aluminum	Phase I	31/35	56.9 to 200.0	56.9 to 7,430.0	907.0
Arsenic	Phase I	7/35	4.0 to 10.0	ND to 9.8	ND
Barium	Phase I	31/35	2.0 to 200.0	8.1 to 1,900.0	350.0
Beryllium	Phase I	1/35	1.0 to 5.0	ND to 1.0	ND
Cadmium	Phase I	2/35	3.0 to 5.0	ND TO 56.9	ND
	Phase II	1/17	0.94 to 5.0	ND to 9.4	ND

TABLE 5-3 (Continued)
CONTAMINANTS DETECTED IN SOLDIER CREEK SURFACE WATER
TINKER AFB – SOLDIER CREEK
RECORD OF DECISION

CHEMICAL	RI PHASE	FREQUENCY OF DETECTION (1)	RANGE OF SAMPLE QUANTITATION LIMITS (2) (ug/L)(3)	RANGE OF DETECTED CONCENTRATIONS (ug/L)(3)	BACKGROUND LEVELS (ug/L)(3)
Calcium	Phase I	31/35	50.8 to 5,000.0	31,200.0 to 117,000.0	64,300.0
Chromium	Phase I	29/35	2.0 to 10.0	ND to 628.0	3.8
	Phase II	10/17	7.0 to 10.0	ND to 36.9	ND
Cobalt	Phase I	11/35	3.0 to 50.0	ND to 324.0	4.9
Copper	Phase I	27/35	16.0 to 25.0	ND to 985.0	ND
Cyanide	Phase I	2/35	10.0	ND to 18.0	ND
	Phase II	1/17	2.2 to 10.0	ND to 10.1	ND
Iron	Phase I	31/35	66.9 to 100.0	66.9 to 4,550.0	1,730.0
Lead	Phase I	29/35	1.0 to 3.0	ND to 325.0	3.9
	Phase II	13/17	2.0 to 3.0	ND to 34.5	1.4 to 6.0
Magnesium	Phase I	31/35	20.0 to 5,000.0	16,400.0 to 40,800.0	21,600.0
Manganese	Phase I	31/35	1.0 to 15.0	11.7 to 3,060.0	1,000.0
Nickel	Phase I	17/35	9.0 to 40.0	ND to 3,560.0	ND
Potassium	Phase I	31/35	345.0 to 5,000.0	921.0 to 6,680.0	921.0
Selenium	Phase I	19/35	2.2 to 5.0	ND to 20.9	ND
Silver	Phase I	2/35	2.0 to 10.0	ND to 13.1	ND
Sodium	Phase I	31/35	504.00 to 5,000.0	15,100.0 to 130,000.0	21,400.0
Vanadium	Phase I	20/35	2.0 to 50.0	ND to 67.0	2.6
Zinc	Phase I	31/35	4.5 to 50.0	4.5 to 2,400.0	24.5

Legend:

ND – Not Detected.

Note:

(1) Number of samples in which the chemical was positively detected over the number of samples available.

(2) The maximum limit is the contract required quantitation limit.

(3) The units of concentration for inorganic constituents are mg/L.

5.3.3 Inorganic Contamination

Many inorganics were detected; however, the maximum concentrations were generally found on-base. All of the inorganics shown in Table 5-3 (pages 5-9 and 5-10) were analyzed during Phase I of the RI; however, cadmium, chromium, cyanide, and lead were the only inorganics analyzed during Phase II of the RI based on a preliminary risk assessment performed after Phase I of the RI was completed. Cyanide was only detected at off-base locations W07 and M13 during Phase I and off-base location M09 during Phase II of the RI. Cadmium was detected only at on-base sample locations during Phase I of the RI. Cadmium was detected only at off-base sample locations during Phase II of the RI. Chromium and lead were detected at both off-base and on-base locations; however, the maximum concentrations were detected on-base. Chromium and lead were also detected at background sample locations. Building 3001 and, potentially, the off-base sources mentioned in Section 5.2.3 are the origin of inorganics in Soldier Creek. Many of the inorganics may also naturally occur in the sediment and surface water.

5.4 Contaminant Characteristics

Acetone, chloroform, methylene chloride, tetrachloroethene, toluene, xylene (total), cadmium, chromium, and lead are the primary sediment contaminants of potential concern based on the frequency of detection and maximum concentrations detected. Acetone, chloroform, methylene chloride, tetrachloroethene, toluene, 1,1,1-trichloroethene, cadmium, chromium, and lead are the primary surface water contaminants of potential concern. Table 5-4 (page 5-12) summarizes the mobility of the primary contaminants of concern and states whether the contaminant poses a carcinogenic or noncarcinogenic health risk to exposed populations.

5.5 Potential Routes of Migration

The potential routes of migration at the Soldier Creek Sediment and Surface Water Operable Unit include infiltration and direct migration through surface and subsurface soil, sediment, and bedrock; groundwater transport; erosion and runoff; and interactions between site aquifers and Soldier Creek.

TABLE 5-4
CHARACTERISTICS OF SELECTED CONTAMINANTS OF CONCERN
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

CHEMICAL OF CONCERN	MEDIA OF CONCERN	MOBILITY	TYPE OF HEALTH RISK
Acetone	Sediment Surface Water	Very Mobile	Noncarcinogenic
Chloroform	Sediment Surface Water	Very Mobile	Probable Carcinogenic
Methylene Chloride	Sediment Surface Water	Extremely Mobile	Carcinogenic
Tetrachloroethene	Sediment Surface Water	Very Mobile	Carcinogenic
Toluene	Sediment Surface Water	Very Mobile	Noncarcinogenic
1,1,1-Trichloroethene	Sediment Surface Water	Very Mobile	Noncarcinogenic
Xylene (total)	Sediment	Very Mobile	Noncarcinogenic
Cadmium	Sediment Surface Water	N/A	Noncarcinogenic
Chromium	Sediment Surface Water	N/A	Noncarcinogenic
Lead	Sediment Surface Water	N/A	Noncarcinogenic

Legend:
N/A - Not Applicable

6.0 SUMMARY OF SITE RISKS

This section summarizes the findings of the baseline risk assessment conducted for the Soldier Creek Sediment and Surface Water Operable Unit. The complete risk assessment is presented in the Risk Assessment report, which is included in the Administrative Record file.

6.1 Overview of Baseline Risk Assessment

A baseline risk assessment was conducted as required under CERCLA to evaluate potential impacts to human health and the environment posed by site contaminants absent a remedial action (i.e., if the operable unit was not cleaned up). Both current and future land use scenarios were evaluated. The risk assessment consisted of the identification of chemicals of potential concern, an exposure assessment, a toxicity assessment, a risk characterization, and an environmental assessment.

6.2 Contaminants of Potential Concern

Contaminants of potential concern (COCs) are contaminants that have been detected at the Soldier Creek Sediment and Surface Water Operable Unit. Sixty-three sediment and 41 surface water chemicals were identified as COCs for this Soldier Creek operable unit. Toxicity information for all of the COCs was evaluated including, where applicable, slope factors and criteria for noncarcinogenic effects. The COCs detected within the media of concern are listed in Tables 5-1 (pages 5-4 and 5-5) and 5-2 (pages 5-8 and 5-9). Twenty-two of these compounds are potential or probable human carcinogens.

For determining risk assessment concentrations, either central tendency or reasonable maximum exposure (RME) calculations are used. Central tendency assumes an average or mean value for the concentrations used in the risk assessment. The RME value is based on the highest exposure that is expected to occur at a site. Risk assessments that use RME values are more conservative than those using central tendency values. The risk assessment for the Soldier Creek Sediment and Surface Water Operable Unit used RME values.

Because of the uncertainty associated with any estimate of exposure concentrations, the 95 percent upper one-sided confidence limit on the arithmetic mean was used as the concentration of the COCs in the risk assessment. This means that, 95 percent of the time, the real mean will not exceed the number that has been chosen as the concentration. For contaminant concentrations reported as "Not Detected" ("ND") in the RI, one half the detection limit was used as the risk assessment concentration.

6.3 Toxicity Assessment

The toxicity assessment characterized available human health and environmental criteria for the COCs and qualitatively related potential chemical exposures (dose) to expected adverse health effects (response). Included in this assessment are the pertinent standards, criteria, advisories, and guidelines developed for the protection of human health and the environment. An explanation of how these values were derived and how they apply is presented below.

Slope factors have been developed by EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. Slope factors, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upperbound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upperbound" reflects the conservative estimate of the risks calculated from the slope factor. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Slope factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. Slope factors for the COCs at the operable unit are presented in Table 6-1 (pages 6-3 and 6-4). The sources of the slope factors are primarily EPA publications and data bases. Specific references are given in Table 6-1 (pages 6-3 and 6-4).

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals, that are likely to be without an appreciable risk of adverse health effects. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated water) can be compared with the RfD. RfDs are derived from human epidemiological or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans).

These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur. RfDs for the COCs are also presented in Table 6-1 (pages 6-3 and 6-4). The sources of the RfDs are primarily EPA publications and data bases. Specific references are given in Table 6-1 (pages 6-3 and 6-4).

6.4 Exposure Assessment

The exposure assessment identified potential pathways and routes for COCs to reach receptors and the estimated contaminant concentration at the points of exposure. A receptor is a human population or any living organism other than a human that may be exposed to contaminants in site media. Exposure pathways by which humans

TABLE 6-1
CHEMICAL-SPECIFIC TOXICITY VALUES USED IN RISK ASSESSMENT
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

CHEMICALS OF POTENTIAL CONCERN	INGESTION EXPOSURES					INHALATION EXPOSURES					DERMAL EXPOSURES			
	SLOPE FACTOR kg-day/mg	WT OF EV	CHRONIC RfD mg/kg-day	REF	TARGET ORGAN SYSTEM	SLOPE FACTOR kg-day/mg	WT OF EV	CHRONIC RfC mg/cu m	REF	TARGET ORGAN SYSTEM	SLOPE FACTOR kg-day/mg	CHRONIC RfD mg/kg-day	PERMEABILITY CONSTANT	REF
Acetone			1.0E-01	I	liver,kidney							8.0E-02		
Benzene	2.9E-02	A		I	leukemia	2.9E-02	A		I	leukemia	3.6E-02		0.111	A
Bromodichloromethane	1.3E-01	B2	2.0E-02	I	liver/kidney		B2		H	NA	1.6E-01	1.6E-02	0.00618	B
Bromoform	7.9E-03	B2	2.0E-02	I	large intestine/liver	3.9E-03	B2		H	NA	9.9E-03	1.6E-02	0.00273	B
Carbon Disulfide			1.0E-01	I	fetotoxic			1.0E-02	H	NA		8.0E-02	0.53	A
Chlorobenzene			2.0E-02	H/I	dvlpmnt/liver,kidney			2.0E-02	H	liver, kidney		1.6E-02	0.0404	B
Chloroethane								1.0E+01	I	fetal effects			0.00901	B
Chloroform	6.1E-03	B2	1.0E-02	I	kidney/fetotoxic,liver	8.1E-02	B2		I	liver	7.6E-03	8.0E-03	0.00958	B
Dibromochloromethane	8.4E-02	C	2.0E-02	I	liver		C		H	NA	1.1E-01	1.6E-02	0.00411	B
1,2-Dichloroethene(cis)			1.0E-02	H	red blood cells							8.0E-03	0.0168	B
1,2-Dichloroethene(trans)			2.0E-02	H	serum chemistry							1.6E-02	0.0168	B
Ethylbenzene		D	1.0E-01	I	liver,kidney							8.0E-02	1.37	A
Methylene Chloride	7.5E-03	B2	6.0E-02	I	liver	1.4E-02	B2	3.0E+00	I/H	lung, liver / NA	9.4E-03	4.8E-02	0.00512	B
Tetrachloroethene	5.1E-02	B2	1.0E-02	H/I	liver/liver	3.3E-03	B2		H	leukemia, liver	6.4E-02	8.0E-03	0.0454	B
Toluene		D	2.0E-01	I	liver,kidney			2.0E+00	H	CNS, eye, nose		1.6E-01	1.01	A
Trichloroethene	1.1E-02	B2		H	liver	1.7E-02	B2		H	lung	1.4E-02		0.0162	B
1,1,1-Trichloroethane		D	9.0E-02	I	liver		D	1.0E+00	H	liver		7.2E-02	0.0176	B
Vinyl Acetate			1.0E+00	H	NA			2.0E-01	I	nasal lesions		8.0E-01		
Acenaphthene			6.0E-02	H	liver							3.0E-02		
Anthracene		D	3.0E-01	I	NA							1.5E-01		
Benzo(a)Anthracene	1.2E+01	B2		M	NA	6.1E+00	B2			NA			0.00792	B
Benzo(a)Pyrene	1.2E+01	B2		M	NA	6.1E+00	B2			NA			0.9	B
Benzo(b)Fluoranthene	1.2E+01	B2		M	NA	6.1E+00	B2			NA			0.62	B
Benzo(g,h,i)Perylene														
Benzo(k)Fluoranthene	1.2E+01	B2		M	NA	6.1E+00	B2			NA				
Benzoic Acid		D	4.0E+00	I	generalized							2.0E+00	0.712	B
bis(2-Ethylhexyl)Phthalate	1.4E-02	B2	2.0E-02	H	liver/liver		B2			NA	2.8E-02	1.0E-02	0.00321	B
Butyl Benzyl Phthalate		C	2.0E-01	I	liver							1.0E-01		
2-Chloronaphthalene														
Chrysene	1.2E+01	B2		M	NA	6.1E+00	B2			NA			0.62	B
Dibenzo(a,h)Anthracene	1.2E+01	B2		M	NA	6.1E+00	B2			NA				
Dibenzofuran														
1,2-Dichlorobenzene		D	9.0E-02	I/H	liver			2.0E-01	H	low body weight		4.5E-02	0.0289	B
1,3-Dichlorobenzene		D		I									0.0573	B
1,4-Dichlorobenzene	2.4E-02	C		H			C	7.0E-01	H	NA/liver, kidney	4.8E-02		0.0804	B
3,3'-Dichlorobenzidine	4.5E-01	B2		H	mammary						9.0E-01		0.0582	B
2,4-Dimethylphenol			2.0E-02	I	blood,neurotoxin							1.0E-02	0.11	A
Di-n-Butylphthalate		D	1.0E-01	I	inc mortality							5.0E-02	1.88	B
Di-n-Octyl Phthalate			2.0E-02	H	liver,kidney							1.0E-02		
Fluoranthene		D	4.0E-02	I	liver,kidney,blood							2.0E-02	0.297	B
Fluorene		D	4.0E-02	I	red blood cells							2.0E-02		
Indeno(1,2,3-cd)Pyrene	1.2E+01	B2		M	NA	6.1E+00	B2			NA			1.31	B

TABLE 6-1 (Continued)
CHEMICAL-SPECIFIC TOXICITY VALUES USED IN RISK ASSESSMENT
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

CHEMICALS OF POTENTIAL CONCERN	INGESTION EXPOSURES					INHALATION EXPOSURES					DERMAL EXPOSURES			
	SLOPE FACTOR kg-day/mg	WT OF EV	CHRONIC RfD mg/kg-day	REF	TARGET ORGAN SYSTEM	SLOPE FACTOR kg-day/mg	WT OF EV	CHRONIC RfC mg/cu m	REF	TARGET ORGAN SYSTEM	SLOPE FACTOR kg-day/mg	CHRONIC RfD mg/kg-day	PERMEABILITY CONSTANT	REF
2-Methylnaphthalene														
2-Methylphenol		C	5.0E-02	I	dec body wt,neurotox		C		H	NA		2.5E-02	0.0157	A
4-Methylphenol		C	5.0E-02	I	dec body wt,neurotox		C		H	NA		2.5E-02	0.0175	A
Naphthalene		D	4.0E-03	H	dec wt gain							2.0E-03	0.0659	B
Phenanthrene		D		I									0.232	B
Pyrene			3.0E-02	I	kidney							1.5E-02		
Aluminum														
Arsenic		A	1.0E-03	H	skin	5.0E+01	A		H	respiratory tract		2.0E-04	0.000857	B
Barium			7.0E-02	I	increased BP			5.0E-04	H	fetotoxic		1.4E-02		
Beryllium	4.3E+00	B2	5.0E-03	I	NA	8.4E+00	B2		H	lung	2.2E+01	1.0E-03	0.00216	B
Cadmium		B1	5.0E-04	I	kidney	6.1E+00	B1		I	respiratory tract		1.0E-04	0.000506	B
Calcium														
Chromium			5.0E-03	I	NA	4.1E+01	A	2.0E-06	I/H	lung / nasal mucosa		1.0E-03	0.0021	A
Cobalt													0.00055	A
Copper		D											0.00101	B
Iron														
Lead													0.000134	B
Magnesium														
Manganese		D	1.0E-01	I	CNS			4.0E-04	I	respiratory tract, CNS		2.0E-02		
Mercury		D	3.0E-04	H	kidney			3.0E-04	H	neurotoxicity		6.0E-05	0.000147	B
Nickel			2.0E-02	H	dec body wt	8.4E-01	A		H	respiratory tract		4.0E-03	0.00108	B
Potassium														
Selenium													0.00081	B
Silver		D	3.0E-03	I	argyria							6.0E-04	0.000539	B
Sodium														
Vanadium			7.0E-03	H	NA							1.4E-03		
Zinc			2.0E-01	I/H	red blood cells		D		I			4.0E-02	0.00098	B
Cyanide		D	2.0E-02	I	thyroid,neurotoxin							4.0E-03	0.0017	B

LEGEND:
RfC = REFERENCE CONCENTRATION
RfD = REFERENCE DOSE
NA = NOT AVAILABLE
dvlpmnt = DEVELOPMENTAL
wt = WEIGHT
dec = DECREASED
inc = INCREASED
BP = BLOOD PRESSURE
CNS = CENTRAL NERVOUS SYSTEM

NOTES:
A - PREDICTED VALUE LISTED IN "EPA RESEARCH AND DEVELOPMENT, INTERIM GUIDANCE FOR DERMAL EXPOSURE ASSESSMENT", MARCH, 1991
B - MODELED VALUE LISTED IN "EPA RESEARCH AND DEVELOPMENT, INTERIM GUIDANCE FOR DERMAL EXPOSURE ASSESSMENT", MARCH, 1991
I - INTEGRATED RESEARCH INFORMATION SYSTEM, (AS OF 9/1/91)
H - HEALTH EFFECTS ASSESSMENT SUMMARY TABLES (1ST QUARTER, FY 1991)
M - MEMO ON CARCINOGENICITY OF BENZO(A)PYRENE AND PAHS, PEI-FUNG HURST, MAR 22, 1991
WT OF EV = EPA's WEIGHT OF EVIDENCE CLASSIFICATION

could be exposed to COCs were identified based on reasonable assumptions about current and future uses of the operable unit. Risks associated with incidental ingestion and dermal contact with sediment and surface water were evaluated for both adult workers and recreational users (child combined with adult) because these exposure pathways represent both current and future land uses. The adult workers are considered potentially exposed on-base populations, and the recreational users are considered potentially exposed off-base populations.

For each potentially significant exposure pathway at Soldier Creek, exposure assumptions were made for RMEs. A RME represents a situation that is more conservative than an average case but is not a worst-case scenario. The RME scenario is developed to reflect the types and extent of exposures that could occur based on the likely or expected use of the operable unit in the future. Ten RME scenarios were examined for the on-base and off-base Soldier Creek stream segments, for both current and future risks:

Off-Base Residents--Current Land Use

- Incidental ingestion and dermal contact with contaminants in surface water while swimming.
- Incidental ingestion and dermal contact with contaminants in surface water while wading.
- Incidental ingestion and dermal contact with contaminants in surface sediment (0 to 6 inches) while swimming or wading.

On-Base Workers--Current Land Use

- Incidental ingestion and dermal contact with contaminants in surface water while performing construction or repair.
- Incidental ingestion and dermal contact with contaminants in surface sediment (0 to 6 inches) while performing construction or repair.

Off-Base Residents--Future Land Use

- Incidental ingestion and dermal contact with contaminants in surface water while wading.
- Incidental ingestion and dermal contact with contaminants in surface water while swimming.
- Incidental ingestion and dermal contact with contaminants in deeper sediment (0 to 5 feet) while swimming or wading.

On-Base Workers--Future Land Use

- Incidental ingestion and dermal contact with contaminants in surface water while performing construction or repair.
- Incidental ingestion and dermal contact with contaminants in deeper sediment (0 to 5 feet) while performing construction or repair.

Sediment, surface water, and groundwater exposure pathways were considered during the risk assessment process. However, only the sediment and surface water exposure pathways are addressed in this discussion because the horizontal and vertical extent of groundwater contamination is not known and because of the complexity of potential groundwater interactions between the operable units at Tinker AFB. The groundwater associated with Soldier Creek will be addressed as a separate operable unit in accordance with the FFA and CERCLA.

The exposure frequency and duration assumptions, as well as the other assumed factors used to calculate the intake and dose absorbed values used in turn to develop the human health risks, depend on the exposure population, exposure pathway, and type of contaminant. The equations used to calculate intakes and absorbed doses for each COC at the Soldier Creek Sediment and Surface Water Operable Unit are as follows:

Residential Exposure: Ingestion of Chemicals in Surface Water While Swimming or Wading (Current and Future Exposures)

$$HIF = \frac{CR \times ET \times EF \times ED}{BW \times AT \times 365}$$

$$Intake\ (mg/kg\text{-}day) = HIF \times CW$$

where,

CW = Chemical Concentration in Water (mg/L)
HIF = Human Intake Factor (L/kg-day)
CR = Contact Rate (liters/hour)
ET = Exposure Time (hours/event)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (period over which exposure is averaged in years)

Construction Worker Exposure: Ingestion of Chemicals in Surface Water (Current and Future Exposures)

$$HIF = \frac{IR \times EF \times ED}{BW \times AT \times 365}$$

$$Intake\ (mg/kg\text{-}day) = HIF \times CW$$

where,

CW = Chemical Concentration in Water (mg/L)
HIF = Human Intake Factor (L/kg-day)
IR = Ingestion Rate (L/day)
ED = Exposure Duration (years)
EF = Exposure Frequency (events/year)
BW = Body Weight (kg)
AT = Averaging Time (years)

Residential Exposure: Ingestion of Chemicals in Sediment While Swimming and Wading (Current and Future Exposures)

$$HIF = \frac{IR \times CF \times FI \times EF \times ED}{BW \times AT \times 365}$$

$$Intake\ (mg/kg\text{-}day) = HIF \times CS$$

where,

HIF = Human Intake Factor (L/kg-day)
CS = Chemical Concentration in Soil (mg/kg)
IR = Ingestion Rate (mg soil/day)
CF = Conversion Factor (10^{-6} kg/mg)
FI = Fraction Ingested from Contaminated Source (unitless)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (years)

Residential Exposure: Dermal Contact of Chemicals in Surface Water While Swimming or Wading (Current and Future Exposures)

$$HIF = \frac{SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT \times 365}$$

$$Absorbed\ Dose\ (mg/kg\text{-}day) = HIF \times CW$$

where,

HIF = Human Intake Factor (L/kg-day)
CW = Chemical Concentration in Water (mg/L)
SA = Skin Surface Area Available for Contact (cm^2)
PC = Chemical-specific Dermal Permeability Constant (cm/hr)
ET = Exposure Time (hours/day)
EF = Exposure Frequency (days/year)
ED = Exposure Duration (years)
CF = Volumetric Conversion Factor for Water (1 L/1000 cm^3)
BW = Body Weight (kg)
AT = Averaging Time (years)

Construction Worker Exposure: Dermal Contact with Chemicals in Surface Water (Current and Future Exposures)

$$HIF = \frac{SA \times ET \times EF \times ED \times CF}{BW \times AT \times 365}$$

$$Absorbed\ Dose\ (mg/kg\text{-}day) = HIF \times PC \times CW$$

where,

HIF = Human Intake Factor (L/kg-day)
CW = Chemical Concentration in Water (mg/L)
PC = Chemical-specific Permeability Constant (cm/hr)
SA = Skin Surface Area Available for Adult Contact (cm^2)
EF = Exposure Frequency (events/year)
ET = Exposure Time (hours/event)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (years)
CF = Conversion Factor of 1 L/1000 cm^2

Residential and Construction Worker Exposure: Dermal Contact With Chemicals in Sediment While Swimming and Wading (Current and Future Exposures)

$$HIF = \frac{CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT \times 365}$$

$$Absorbed\ Dose\ (mg/kg\text{-}day) = CS \times HIF$$

where,

CW = Chemical Concentration in Water (mg/kg)
CF = Conversion Factor (10^{-6} kg/mg)
HIF = Human Intake Factor (L/kg-day)
SA = Skin Surface Area Available for Contact (cm^2/event)
AF = Soil to Skin Adherence Factor (mg/cm^2)
ABS = Absorption Factor (unitless)
EF = Exposure Frequency (events/year)
ED = Exposure Duration (years)
BW = Body Weight (kg)
AT = Averaging Time (years)

The exposure assumptions used in the baseline risk assessment for the Soldier Creek Sediment and Surface Water Operable Unit are presented in Table 6-2 (page 6-10). Intakes and absorbed dose values were calculated for each chemical of concern under each exposure pathway and risk segment. Because of the large number of calculated values, they are not presented in the ROD. However, this information is presented in Appendix C of the Risk Assessment report, which is available in the Administrative Record file.

6.5 Risk Characterization

The risk characterization quantifies present or potential future risks to human health that may result from exposure to the COCs found at the operable unit. The site-specific risk values were estimated by incorporating information from the toxicity and exposure assessments. When sufficient data are available, two quantitative evaluations are made: the incremental risk to the individual resulting from exposure to a carcinogen; or, for noncarcinogens, a numerical index or ratio of the exposure dose level to an acceptable reference dose. Table 6-3 (pages 6-11 and 6-12) presents the total carcinogenic and noncarcinogenic risk associated with each COC.

For every segment [as shown on Figure 1-2 (page 1-3)] and each exposure pathway, a risk was calculated. The risks associated with each pathway were summed to obtain an overall noncarcinogenic and carcinogenic risk for each segment. A back

TABLE 6–2
EXPOSURE ASSUMPTIONS
TINKER AFB – SOLDIER CREEK
RECORD OF DECISION

EXPOSURE ASSUMPTION	INGESTION OF SEDIMENT	INGESTION OF SURFACE WATER	DERMAL CONTACT WITH SEDIMENT	DERMAL CONTACT WITH SURFACE WATER
Absorption Factor				
Volatile Organics	NA	NA	0.25	NA
Semivolatile Organics	NA	NA	0.1	NA
Metal Inorganics	NA	NA	0.01	NA
Averaging Time (years)				
Carcinogenic	70	70	70	70
Carcinogenic (Adult Worker)	25	25	25	25
Noncarcinogenic	30	30	30	30
Body Weight (kg)				
Adult Worker	70	70	70	70
Adult	57.1	57.1	57.1	57.1
Child	15.1	15.1	15.1	15.1
Contact Rate (L/hr)				
Swimming	NA	0.05	NA	NA
Wading	NA	0.005	NA	NA
Exposure Duration (years)				
Adult	25	25	25	25
Child	5	5	5	5
Exposure Frequency (day/year)				
Adult Worker	1	1	1	1
Adult	4	4	4	4
Child	17	17	17	17
Exposure Time (hours/day)				
Adult Worker	NA	NA	NA	8
Adult	NA	2	NA	2
Child	NA	6	NA	
Fraction Ingested	1	NA	NA	NA
Ingestion Rate (mg/day)				
Adult Worker	50	0.005 L/day	NA	NA
Adult	100	NA	NA	NA
Child	200	NA	NA	NA
Skin Surface Available for Contact (sqcm)				
Adult Worker	NA	NA	9800	9800
Adult	NA	NA	8620	18200
Child	NA	NA	7200	7200
Soil to Skin Adherence Factor (mg/sqcm)	NA	NA	1.45	NA

Legend:
NA – Not Applicable.

Notes:
(1) Exposure assumptions are for current and future exposures from swimming and wading (adult and child) or construction work (adult worker). If adult, child, or adult worker receptor designation is not listed, exposure assumptions are the same for each receptor.

TABLE 6-3
SUMMARY OF TOTAL CARCINOGENIC AND NONCARCINOGENIC RISKS FOR EACH CONTAMINANT OF CONCERN
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

ANALYTE (a)	Risk Assessment Concentration (mg/kg)	Total Non-carcinogenic Risk(b)	Total Carcinogenic Risk(c)	Non-carcinogenic Cleanup Level (mg/kg)(d)	Carcinogenic Cleanup Level (mg/kg) (1.00E-6)(e)	Carcinogenic Cleanup Level (mg/kg) (1.00E-4)(f)
SEDIMENT						
ACETONE	1.7E+00	4.1E-05		4.1E+04		
BENZENE	5.0E-03		1.5E-10		3.3E+01	3.3E+03
CARBON DISULFIDE	2.1E-02	3.6E-08		5.7E+05		
CHLOROBENZENE	6.1E-03	7.4E-07		8.3E+03		
CHLOROETHANE	1.3E-02					
CHLOROFORM	2.8E-02	6.8E-06	1.8E-10	4.1E+03	1.6E+02	1.6E+04
1,2-DICHLOROETHENE (TOTAL)	1.8E+01	3.2E-04		5.7E+04		
ETHYLBENZENE	5.0E-03	8.8E-09		5.7E+05		
METHYLENE CHLORIDE	1.0E-01	4.0E-06	7.8E-10	2.5E+04	1.3E+02	1.3E+04
TETRACHLOROETHENE	5.0E-03	1.2E-06	2.7E-10	4.1E+03	1.9E+01	1.9E+03
TRICHLOROETHENE	4.2E-01		2.9E-10		1.4E+03	1.4E+05
TOLUENE	5.0E-03	6.0E-08		8.3E+04		
VINYL ACETATE	5.0E-03	1.0E-06		1.0E+06		
XYLENE (TOTAL)	5.2E-03	6.3E-09		8.3E+05		
ACENAPHTHENE	1.7E-01	4.4E-06		3.8E+04		
ANTHRACENE	1.7E-01	8.8E-07		1.9E+05		
BENZO(A)ANTHRACENE	1.7E-01		1.0E-07		1.6E+00	1.6E+02
BENZO(A)PYRENE	2.5E-01		1.5E-07		1.6E+00	1.6E+02
BENZO(B)FLUORANTHENE	1.9E-01		1.1E-07		1.6E+00	1.6E+02
BENZO(K)FLUORANTHENE	1.8E-01		1.1E-07		1.6E+00	1.6E+02
BIS(2-ETHYLHEXYL)PHTHALATE	4.2E+00	3.3E-04	4.0E-08	1.3E+04	1.0E+02	1.0E+04
BENZO(G,H,I)PERYLENE	1.2E+00					
BUTYLBENZYLPHTHALATE	1.7E-01	1.3E-06		1.3E+05		
2-CHLORONAPHTHALENE	5.0E-01					
CHRYSENE	2.0E-01		1.2E-07		1.6E+00	1.6E+02
DIBENZ(A,H)ANTHRACENE	1.7E-01		1.4E-09		1.2E+02	1.2E+04
DIBENZOFURAN	2.4E-01					
1,3-DICHLOROBENZENE	1.8E-01					
1,4-DICHLOROBENZENE	7.1E-01		6.9E-10		1.0E+03	1.0E+05
1,2-DICHLOROBENZENE	5.4E-01	6.8E-07		7.9E+05		
3,3'-DICHLOROBENZIDINE	4.9E-01		9.0E-09		5.5E+01	5.5E+03
DI-N-BUTYLPHTHALATE	1.7E-01	2.6E-06		6.3E+04		
DI-N-OCTYLPHTHALATE	1.7E-01	1.3E-05		1.3E+04		
FLUORANTHENE	3.8E-01	1.5E-05		2.5E+04		
FLUORENE	1.7E-01	6.6E-06		2.5E+04		
2-METHYLNAPHTHALENE	1.1E+00					
2-METHYLPHENOL	1.7E-01	3.7E-07		4.4E+05		
4-METHYLPHENOL	1.7E-01	3.7E-07		4.4E+05		
2,4-DIMETHYLPHENOL	1.7E-01	9.3E-07		1.8E+05		
INDENO(1,2,3-CD)PYRENE	1.2E+00		9.6E-09		1.2E+02	1.2E+04
NAPHTHALENE	1.7E-01	6.6E-05		2.5E+03		
PHENANTHRENE	2.6E-01					
PYRENE	4.7E-01	2.5E-05		1.9E+04		
ALUMINUM	1.4E+04					
ARSENIC	3.9E+00	1.9E-03		2.1E+03		
BARIUM	9.1E+02	6.4E-03		1.4E+05		
CADMIUM	1.6E+01	1.5E-02		1.0E+03		
CALCIUM	4.3E+04					
CHROMIUM	3.4E+02	3.3E-02		1.0E+04		
COBALT	2.1E+01					
COPPER	1.4E+02					
CYANIDE	1.8E+00	2.7E-06		6.7E+05		
IRON	1.5E+04					
LEAD	1.3E+02					

TABLE 6-3 (Continued)
SUMMARY OF TOTAL CARCINOGENIC AND NONCARCINOGENIC RISKS FOR EACH CONTAMINANT OF CONCERN
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

ANALYTE (a)	Risk Assessment Concentration (mg/kg)	Total Non-carcinogenic Risk(b)	Total Carcinogenic Risk(c)	Non-carcinogenic Cleanup Level (mg/kg)(d)	Carcinogenic Cleanup Level (mg/kg) (1.00E-6)(e)	Carcinogenic Cleanup Level (mg/kg) (1.00E-4)(f)
MAGNESIUM	1.3E+04					
MANGANESE	5.5E+02	2.7E-03		2.1E+05		
MERCURY	2.2E+00	3.6E-03		6.2E+02		
NICKEL	4.9E+01	1.2E-03		4.1E+04		
POTASSIUM	1.3E+03					
SELENIUM	3.3E+00					
SILVER	4.3E+00	6.9E-04		6.2E+03		
VANADIUM	2.6E+01	1.8E-03		1.4E+04		
ZINC	1.3E+02	3.2E-04		4.1E+05		
SURFACE WATER (g)						
ACETONE	5.1E-02	1.0E-04		5.0E+02		
BENZENE	5.0E-03		2.5E-07		2.0E-02	2.0E+00
BROMODICHLOROMETHANE	5.2E-03	6.2E-06	3.0E-09	8.4E+02	1.7E+00	1.7E+02
BROMOFORM	7.1E-03	3.8E-06	2.1E-10	1.9E+03	3.3E+01	3.3E+03
CARBON DISULFIDE	5.0E-03	9.4E-04		5.3E+00		
CHLOROBENZENE	5.0E-03	4.0E-04		1.3E+01		
CHLOROFORM	5.0E-03	2.5E-04	6.6E-09	2.0E+01	7.6E-01	7.6E+01
DIBROMOCHLOROMETHANE	5.0E-03	4.0E-06	2.5E-09	1.3E+03	2.0E+00	2.0E+02
1,2-DICHLOROETHENE (TOTAL)	8.6E-03	5.6E-05		1.5E+02		
METHYLENE CHLORIDE	5.2E-01	3.0E-03	5.9E-07	1.7E+02	8.9E-01	8.9E+01
TETRACHLOROETHENE	5.0E-03	8.7E-05	1.6E-08	5.7E+01	3.1E-01	3.1E+01
1,1,1-TRICHLOROETHANE	5.0E-03	4.4E-05		1.1E+02		
TRICHLOROETHENE	5.0E-03		1.8E-08		2.8E-01	2.8E+
TOLUENE	5.0E-03	8.9E-04		5.6E+00		
XYLENE (TOTAL)	5.0E-03	4.7E-07		1.1E+04		
BENZO(G,H,I)PERYLENE	5.2E-03					
BENZOIC ACID	5.0E-03	5.0E-05		1.0E+02		
CHRYSENE	5.0E-03		4.2E-09		1.2E+00	1.2E+02
FLUORANTHENE	5.0E-03	2.3E-04		2.2E+01		
PYRENE	5.0E-03	8.5E-07		5.9E+03		
ALUMINUM	4.1E-01					
ARSENIC	7.4E-03	9.2E-04		8.1E+00		
BARIUM	2.8E-01	1.1E-03		2.5E+02		
BERYLLIUM	2.5E-03	1.7E-05	1.3E-07	1.5E+02	2.0E-02	2.0E+00
CADMIUM	8.3E-03	4.0E-03		2.1E+00		
CALCIUM	4.8E+01					
CHROMIUM	3.5E-02	3.3E-03		1.1E+01		
COBALT	2.1E-01					
COPPER	6.2E-01					
CYANIDE	1.6E-02	3.2E-04		4.9E+01		
IRON	3.5E-01					
LEAD	2.0E-02					
MAGNESIUM	2.2E+01					
MANGANESE	3.0E-01	8.4E-04		3.5E+02		
NICKEL	1.8E-02	3.0E-04		6.2E+01		
POTASSIUM	6.3E+00					
SELENIUM	6.7E-03					
SILVER	1.0E-02	2.8E-05		3.5E+02		
SODIUM	1.3E+02					
VANADIUM	5.0E-02	8.9E-05		5.6E+02		
ZINC	1.5E+00	1.2E-04		1.3E+04		

(a) Analytes are evaluated using the most conservative scenario for each analyte.
(b) Total noncarcinogenic risks are the summation of two exposure pathways, Incidental Ingestion and Dermal Contact.
(c) Total carcinogenic risks are the summation of two exposure pathways, Incidental Ingestion and Dermal Contact.
(d) Cleanup Level = (Risk Assessment Concentration/risk)(HI) where HI=1.0
(e) Cleanup Level = (Risk Assessment Concentration/risk)(1.00E-6)
(f) Cleanup Level = (Risk Assessment Concentration/risk)(1.00E-4)
(g) Units of concentration for surface water constituents are mg/L.

calculation was performed using the risk calculated from the most conservative exposure scenario and the contaminant concentration to determine the risk-based cleanup goal for each contaminant. These cleanup levels are presented in Table 6-3 (pages 6-11 and 6-12).

6.5.1 Noncarcinogenic Risk

The EPA has developed standards, guidelines, and criteria that provide levels of intakes considered to protect human populations from possible adverse effects resulting from chemical exposures. The ratio of the estimated chemical intake to the RfD provides a numerical measure of the potential for adverse effects. This ratio is referred to as the chronic hazard quotient (HQ). In the absence of federal standards, the HQ is compared with the most applicable criteria or guideline for intakes.

The estimated chronic chemical intake, in mg/kg-day, is estimated using the exposure assumptions and the actual site data. The chemical intake is then compared with the RfD to determine if chronic exposure to the contaminated medium presents a risk. Because certain standards are derived for protection against either subchronic or chronic exposures, chemical intakes for noncarcinogens are developed for subchronic and chronic exposures, and the associated risks are assessed as appropriate.

All of the HQ values for the chemicals within each exposure pathway are added together to yield the hazard index (HI). The HI provides a useful reference point for gauging the potential significance of multiple contaminant exposures within a single medium or across media. A HI value of less than 1.0 indicates little concern for noncarcinogenic effects, and a HI value greater than or equal to 1.0 indicates an increased level of concern.

Indices were calculated for all of the COCs at the operable unit. The results indicate that HIs for all current and future human health exposures associated with Soldier Creek surface water and sediment are less than 1.0. Summaries of the noncarcinogenic risks associated with current and future land use of the Soldier Creek Sediment and Surface Water Operable Unit are presented in Tables 6-4 (page 6-14) and 6-5 (page 6-15), respectively.

6.5.2 Carcinogenic Risk

For carcinogens or suspected carcinogens, a quantitative risk assessment involves calculating risk levels considered to represent the probability or range of probabilities of developing additional incidence of cancer under the prescribed exposure conditions. Carcinogenic risk estimates, expressed as additional incidence of cancer, are determined by multiplying the slope factor by the projected exposure dose level. It is the slope factor, expressed in $(mg/kg\text{-}day)^{-1}$, that converts the estimated exposure dose level, expressed in mg/kg-day, to incremental risk. These risks are probabilities that are generally expressed in scientific notation (e.g., 1E-06). An excess lifetime

TABLE 6-4
SUMMARY OF NONCARCINOGENIC RISKS, CURRENT LAND USE
SURFACE WATER AND SEDIMENT EXPOSURES
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

POPULATION	MEDIUM	EXPOSURE PATHWAY	RISK (HI)
OFF-BASE RESIDENTS	SURFACE WATER - SEGMENT A	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	SHALLOW SEDIMENT - SEGMENT A	INCIDENTAL INGESTION	1.00E-03
		DERMAL CONTACT	4.00E-03
		SEGMENT A RISK (HI):	**5.00E-03**
	SURFACE WATER - SEGMENT B	INCIDENTAL INGESTION-WADING	1.00E-04
		DERMAL CONTACT-WADING	8.00E-04
	SHALLOW SEDIMENT - SEGMENT B	INCIDENTAL INGESTION	4.00E-03
		DERMAL CONTACT	1.00E-02
		SEGMENT B RISK (HI):	**2.00E-02**
	SURFACE WATER - SEGMENT M1	INCIDENTAL INGESTION-WADING	4.60E-04
		DERMAL CONTACT-WADING	3.20E-03
	SHALLOW SEDIMENT - SEGMENT M1	INCIDENTAL INGESTION	2.00E-02
		DERMAL CONTACT	6.00E-02
		SEGMENT M1 RISK (HI):	**8.37E-02**
	SURFACE WATER - SEGMENT M2	INCIDENTAL INGESTION-SWIMMING	2.37E-03
		DERMAL CONTACT-SWIMMING	4.93E-03
	SHALLOW SEDIMENT - SEGMENT M2	INCIDENTAL INGESTION	3.00E-03
		DERMAL CONTACT	9.00E-03
		SEGMENT M2 RISK (HI):	**1.93E-02**
	SURFACE WATER - SEGMENT M3	INCIDENTAL INGESTION-SWIMMING	1.41E-02
		DERMAL CONTACT-SWIMMING	2.75E-03
	SHALLOW SEDIMENT - SEGMENT M3	INCIDENTAL INGESTION	1.00E-03
		DERMAL CONTACT	4.00E-03
		SEGMENT M3 RISK (HI):	**2.19E-02**
	SURFACE WATER - SEGMENT E2	INCIDENTAL INGESTION-SWIMMING	6.77E-03
		DERMAL CONTACT-SWIMMING	6.77E-03
	SHALLOW SEDIMENT - SEGMENT E2	INCIDENTAL INGESTION	3.00E-03
		DERMAL CONTACT	1.00E-02
		SEGMENT E2 RISK (HI):	**2.65E-02**
	SURFACE WATER - SEGMENT W2	INCIDENTAL INGESTION-SWIMMING	1.06E-03
		DERMAL CONTACT-SWIMMING	1.83E-03
	SHALLOW SEDIMENT - SEGMENT W2	INCIDENTAL INGESTION	2.00E-02
		DERMAL CONTACT	5.00E-02
		SEGMENT W2 RISK (HI):	**7.29E-02**
ON-BASE WORKERS	SURFACE WATER - SEGMENT E1	INCIDENTAL INGESTION-SWIMMING	5.00E-06
		DERMAL CONTACT-SWIMMING	7.00E-04
	SHALLOW SEDIMENT - SEGMENT E1	INCIDENTAL INGESTION	2.00E-05
		DERMAL CONTACT	1.00E-02
		SEGMENT E1 RISK (HI):	**1.07E-02**
	SURFACE WATER - SEGMENT W1	INCIDENTAL INGESTION-SWIMMING	4.00E-05
		DERMAL CONTACT-SWIMMING	4.00E-03
	SHALLOW SEDIMENT - SEGMENT W1	INCIDENTAL INGESTION	8.00E-04
		DERMAL CONTACT	1.00E-02
		SEGMENT W1 RISK (HI):	**2.00E-02**

Legend:
-- Indicates that a HI could not be calculated for the pathway because the stream was dry on the sampling date.

TABLE 6-5
SUMMARY OF NONCARCINOGENIC RISKS, FUTURE LAND USE
SURFACE WATER AND SEDIMENT EXPOSURES
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

POPULATION	MEDIUM	EXPOSURE PATHWAY	RISK (HI)
OFF-BASE RESIDENTS	SURFACE WATER - SEGMENT A	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	DEEP SEDIMENT - SEGMENT A	INCIDENTAL INGESTION	--
		DERMAL CONTACT	--
		SEGMENT A RISK (HI):	--
	SURFACE WATER - SEGMENT B	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	DEEP SEDIMENT - SEGMENT B	INCIDENTAL INGESTION	--
		DERMAL CONTACT	--
		SEGMENT B RISK (HI):	--
	SURFACE WATER - SEGMENT M1	INCIDENTAL INGESTION-WADING	4.60E-04
		DERMAL CONTACT-WADING	3.20E-03
	DEEP SEDIMENT - SEGMENT M1	INCIDENTAL INGESTION	1.30E-02
		DERMAL CONTACT	4.00E-02
		SEGMENT M1 RISK (HI):	**5.67E-02**
	SURFACE WATER - SEGMENT M2	INCIDENTAL INGESTION-SWIMMING	2.37E-03
		DERMAL CONTACT-SWIMMING	4.93E-03
	DEEP SEDIMENT - SEGMENT M2	INCIDENTAL INGESTION	5.20E-03
		DERMAL CONTACT	2.00E-02
		SEGMENT M2 RISK (HI):	**3.25E-02**
	SURFACE WATER - SEGMENT M3	INCIDENTAL INGESTION-SWIMMING	1.41E-02
		DERMAL CONTACT-SWIMMING	2.75E-03
	DEEP SEDIMENT - SEGMENT M3	INCIDENTAL INGESTION	7.10E-04
		DERMAL CONTACT	2.00E-03
		SEGMENT M3 RISK (HI):	**1.96E-02**
	SURFACE WATER - SEGMENT E2	INCIDENTAL INGESTION-SWIMMING	6.77E-03
		DERMAL CONTACT-SWIMMING	6.49E-03
	DEEP SEDIMENT - SEGMENT E2	INCIDENTAL INGESTION	3.50E-03
		DERMAL CONTACT	1.00E-02
		SEGMENT E2 RISK (HI):	**2.68E-02**
	SURFACE WATER - SEGMENT W2	INCIDENTAL INGESTION-SWIMMING	1.06E-03
		DERMAL CONTACT-SWIMMING	1.83E-03
	DEEP SEDIMENT - SEGMENT W2	INCIDENTAL INGESTION	1.20E-02
		DERMAL CONTACT	4.00E-02
		SEGMENT W2 RISK (HI):	**5.49E-02**
ON-BASE WORKERS	SURFACE WATER - SEGMENT E1	INCIDENTAL INGESTION-SWIMMING	5.00E-06
		DERMAL CONTACT-SWIMMING	7.00E-04
	DEEP SEDIMENT - SEGMENT E1	INCIDENTAL INGESTION	5.00E-04
		DERMAL CONTACT	7.00E-03
		SEGMENT E1 RISK (HI):	**8.21E-03**
	SURFACE WATER - SEGMENT W1	INCIDENTAL INGESTION-SWIMMING	4.00E-05
		DERMAL CONTACT-SWIMMING	4.00E-03
	DEEP SEDIMENT - SEGMENT W1	INCIDENTAL INGESTION	3.00E-04
		DERMAL CONTACT	5.00E-03
		SEGMENT W1 RISK (HI):	**1.00E-02**

Legend
-- Indicates that a HI could not be calculated for the pathway because the stream was dry on the sampling date.

cancer risk of 1E-06 indicates that, as a plausible upper bound, one additional case of cancer per one million population occurs as a result of site-related exposure conditions. The 1E-06 risk is used as a point of departure for determining remediation goals for alternatives when ARARs are not available or sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure. EPA has determined that remedial actions should minimize the risk at a site so that it falls within a range of 1E-04 (one additional case of cancer per ten thousand) to 1E-06. This is considered to be a generally acceptable risk range. The risk assessment for the Soldier Creek Sediment and Surface Water Operable Unit indicated that the carcinogenic risks for all current and future RME exposures associated with the surface water and sediment are within this specified risk range in the absence of conducting an intrusive remedial action at the operable unit. Summaries of the carcinogenic risks associated with current and future land use of the Soldier Creek Sediment and Surface Water Operable Unit are presented in Tables 6-6 (page 6-17) and 6-7 (page 6-18), respectively.

6.5.3 Environmental Evaluation

The qualitative environmental assessment conducted as a part of the baseline risk assessment included selecting COCs, exposure characterization, and risk characterization. Because detailed field surveys and toxicity testing were not conducted during the RI, it was difficult to estimate the risk of site contaminants to aquatic and terrestrial species that inhabit the Soldier Creek Sediment and Surface Water Operable Unit ecosystem. The assessment focused on the effect of the COCs on general populations of species that are typically found in the operable unit area. The COCs were selected on the basis of positive identification in samples collected during the RI with special consideration for those chemicals that have the greatest potential for injury to environmental receptors or that are toxic to animals. The exposure characterization identified potential receptors and exposure pathways of contaminant migration to these receptors. Receptors identified included birds, mammals, amphibians, reptiles, and plants documented or expected to occur in the area of the Soldier Creek Sediment and Surface Water Operable Unit. Exposure pathways for each type of receptor were identified and included dermal contact, ingestion, inhalation, and respiration. The qualitative risk characterization evaluated the potential risks to aquatic and terrestrial species. The presence of some metals in Soldier Creek may present an environmental concern to aquatic species; however, this cannot be fully evaluated without conducting a quantitative ecological assessment. More information is also needed to fully define the risk to terrestrial inhabitants. A more detailed discussion of the environmental evaluation is presented in the risk assessment report, which is available in the Administrative Record file.

TABLE 6-6
SUMMARY OF CARCINOGENIC RISKS, CURRENT LAND USE
SURFACE WATER AND SEDIMENT EXPOSURES
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

POPULATION	MEDIUM	EXPOSURE PATHWAY	RISK
OFF-BASE RESIDENTS	SURFACE WATER - SEGMENT A	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	SHALLOW SEDIMENT - SEGMENT A	INCIDENTAL INGESTION	4.60E-07
		DERMAL CONTACT	5.00E-09
		SEGMENT A RISK:	**4.65E-07**
	SURFACE WATER - SEGMENT B	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	SHALLOW SEDIMENT - SEGMENT B	INCIDENTAL INGESTION	4.80E-10
		DERMAL CONTACT	7.00E-09
		SEGMENT B RISK:	**7.48E-09**
	SURFACE WATER - SEGMENT M1	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	SHALLOW SEDIMENT - SEGMENT M1	INCIDENTAL INGESTION	3.60E-10
		DERMAL CONTACT	4.00E-09
		SEGMENT M1 RISK:	**4.36E-09**
	SURFACE WATER - SEGMENT M2	INCIDENTAL INGESTION-SWIMMING	1.50E-08
		DERMAL CONTACT-SWIMMING	2.50E-07
	SHALLOW SEDIMENT - SEGMENT M2	INCIDENTAL INGESTION	2.00E-07
		DERMAL CONTACT	6.00E-09
		SEGMENT M2 RISK:	**4.71E-07**
	SURFACE WATER - SEGMENT M3	INCIDENTAL INGESTION-SWIMMING	2.20E-09
		DERMAL CONTACT-SWIMMING	4.37E-09
	SHALLOW SEDIMENT - SEGMENT M3	INCIDENTAL INGESTION	2.70E-10
		DERMAL CONTACT	4.00E-09
		SEGMENT M3 RISK:	**1.08E-08**
	SURFACE WATER - SEGMENT E2	INCIDENTAL INGESTION-SWIMMING	3.00E-07
		DERMAL CONTACT-SWIMMING	5.40E-07
	SHALLOW SEDIMENT - SEGMENT E2	INCIDENTAL INGESTION	4.90E-10
		DERMAL CONTACT	6.00E-09
		SEGMENT E2 RISK:	**8.46E-07**
	SURFACE WATER - SEGMENT W2	INCIDENTAL INGESTION-SWIMMING	--
		DERMAL CONTACT-SWIMMING	--
	SHALLOW SEDIMENT - SEGMENT W2	INCIDENTAL INGESTION	5.60E-07
		DERMAL CONTACT	4.00E-08
		SEGMENT W2 RISK:	**6.00E-07**
ON-BASE WORKERS	SURFACE WATER - SEGMENT E1	INCIDENTAL INGESTION	4.00E-09
		DERMAL CONTACT	2.00E-08
	SHALLOW SEDIMENT - SEGMENT E1	INCIDENTAL INGESTION	8.00E-08
		DERMAL CONTACT	9.00E-08
		SEGMENT E1 RISK:	**1.94E-07**
	SURFACE WATER - SEGMENT W1	INCIDENTAL INGESTION	8.00E-10
		DERMAL CONTACT	1.00E-07
	SHALLOW SEDIMENT - SEGMENT W1	INCIDENTAL INGESTION	1.00E-07
		DERMAL CONTACT	3.00E-08
		SEGMENT W1 RISK:	**3.00E-07**

Legend:
-- Indicates that a risk could not be calculated for the pathway because the stream was dry on the sampling date or that the contaminants detected in the segment do not pose a carcinogenic health risk.

TABLE 6-7
SUMMARY OF CARCINOGENIC RISKS, FUTURE LAND USE
SURFACE WATER AND SEDIMENT EXPOSURES
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

POPULATION	MEDIUM	EXPOSURE PATHWAY	RISK
OFF-BASE RESIDENTS	SURFACE WATER - SEGMENT A	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	DEEP SEDIMENT - SEGMENT A	INCIDENTAL INGESTION	--
		DERMAL CONTACT	--
		SEGMENT A RISK:	--
	SURFACE WATER - SEGMENT B	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	DEEP SEDIMENT - SEGMENT B	INCIDENTAL INGESTION	--
		DERMAL CONTACT	--
		SEGMENT B RISK:	--
	SURFACE WATER - SEGMENT M1	INCIDENTAL INGESTION-WADING	--
		DERMAL CONTACT-WADING	--
	DEEP SEDIMENT - SEGMENT M1	INCIDENTAL INGESTION	3.47E-10
		DERMAL CONTACT	4.00E-09
		SEGMENT M1 RISK:	**4.35E-09**
	SURFACE WATER - SEGMENT M2	INCIDENTAL INGESTION-SWIMMING	1.68E-08
		DERMAL CONTACT-SWIMMING	2.58E-07
	DEEP SEDIMENT - SEGMENT M2	INCIDENTAL INGESTION	1.51E-07
		DERMAL CONTACT	5.00E-09
		SEGMENT M2 RISK:	**4.31E**
	SURFACE WATER - SEGMENT M3	INCIDENTAL INGESTION-SWIMMING	2.22E-09
		DERMAL CONTACT-SWIMMING	4.37E-09
	DEEP SEDIMENT - SEGMENT M3	INCIDENTAL INGESTION	4.87E-10
		DERMAL CONTACT	6.00E-09
		SEGMENT M3 RISK:	**1.31E-08**
	SURFACE WATER - SEGMENT E2	INCIDENTAL INGESTION-SWIMMING	2.95E-07
		DERMAL CONTACT-SWIMMING	5.40E-07
	DEEP SEDIMENT - SEGMENT E2	INCIDENTAL INGESTION	4.57E-10
		DERMAL CONTACT	6.00E-09
		SEGMENT E2 RISK:	**8.41E-07**
	SURFACE WATER - SEGMENT W2	INCIDENTAL INGESTION-SWIMMING	--
		DERMAL CONTACT-SWIMMING	--
	DEEP SEDIMENT - SEGMENT W2	INCIDENTAL INGESTION	5.51E-07
		DERMAL CONTACT	4.00E-08
		SEGMENT W2 RISK:	**5.91E-07**
ON-BASE WORKERS	SURFACE WATER - SEGMENT E1	INCIDENTAL INGESTION	4.00E-09
		DERMAL CONTACT	2.00E-08
	DEEP SEDIMENT - SEGMENT E1	INCIDENTAL INGESTION	5.00E-08
		DERMAL CONTACT	4.00E-08
		SEGMENT E1 RISK:	**1.14E-07**
	SURFACE WATER - SEGMENT W1	INCIDENTAL INGESTION	8.00E-10
		DERMAL CONTACT	1.00E-07
	DEEP SEDIMENT - SEGMENT W1	INCIDENTAL INGESTION	8.00E-08
		DERMAL CONTACT	2.00E-08
		SEGMENT W1 RISK:	**2.01E-07**

Legend:
-- Indicates that a risk could not be calculated for the pathway becuase the stream was dry on the sampling date or that the contaminants detected in the segment do not pose a carcinogenic health risk.

The environmental assessment also identified the potentially threatened or endangered species that are likely to inhabit, or are known to inhabit, the area of Tinker AFB and the Soldier Creek Sediment and Surface Water Operable Unit. These include the Oklahoma beardtongue, Ozark poverty grass, the Prairie mole cricket, Swainson's hawk, and the Texas horned lizard.

One jurisdictional wetland exists along East Soldier Creek in the area of the IWTP. The wetland is the result of a manmade structure and is not considered by the State of Oklahoma to be an official wetland area.

6.5.4 Uncertainties

Regardless of the type of risk estimate developed, it should be emphasized that all estimates of risk are based upon numerous assumptions and uncertainties. The factors that contribute uncertainty include the estimates of the exposure concentrations, daily intakes, and toxicity information. These factors include chemicals not included in the assessment, exposure pathways not considered, derivation of exposure point concentrations, intake uncertainty, toxicological dose-response and toxicity value uncertainty, and synergistic effects of multiple contaminants.

The quantitative risk characterization processes that were identified as contributing uncertainty to the risk assessment include the fact that the slope factors used to calculate oral carcinogenic risks for carcinogenic polynuclear aromatic hydrocarbons (PAH) compounds were based on benzo(a)pyrene. There are also uncertainties associated with summing cancer risks or hazard indices for different chemicals. This assumption of dose additivity ignores possible synergism or antagonism among chemicals and differences in mechanisms of action and metabolism. It is not known what effects these uncertainties have on the total risk estimation.

Another important uncertainty concerns the fact that risk calculations for dermal exposure to carcinogenic PAHs were not performed. It is likely that risk for exposure to carcinogenic PAHs is underestimated. However, because carcinogenic PAHs are not one of the primary contributors to carcinogenic risk at the Soldier Creek Sediment and Surface Water Operable Unit, these factors are relatively less important in the overall view of risk levels. These uncertainties and the uncertainties discussed in previous sections need to be considered when evaluating the results of the risk assessment and when making risk management decisions for the operable unit.

EPA risk assessments are required to consider a "central tendency exposure" and "high end exposure." The central tendency exposure is the average exposure that is expected to occur at the site. The CERCLA RME is considered a "high end exposure." The RME exposure is the maximum exposure that is reasonably expected

to occur at a site. The central tendency exposure provides an indication of the degree of uncertainty in the risk assessment.

Using RME exposure assumptions in the baseline risk assessment resulted in excess cancer risks of less than one excess cancer in one million individuals (1E-06). The EPA acceptable risk range specified in the NCP is one excess cancer in ten thousand individuals (1E-04) to one excess cancer in one million individuals (1E-06). Using central tendency exposure assumptions in the risk assessment would result in even lower risk estimates by approximately a factor of four. Therefore, the risk assessment using either exposure regime would result in excess cancer risks less than one excess cancer in one million individuals (1E-06), the lower end of EPA acceptable risk range.

6.5.5 *Cleanup Goals*

The cleanup, or remediation, goals presented in Table 6-3 (pages 6-11 and 6-12) are the risk-based levels that determine the extent of site media requiring remediation. For example, sediment that exceeded the 1E-04 carcinogenic cleanup level or the noncarcinogenic cleanup level would require some form of remediation. The 1E-06 carcinogenic cleanup level is the point of departure for determining if remediation is required at a site. For values that fall within the range of 1E-04 and 1E-06, cleanup may be necessary depending upon site and contaminant characteristics, such as frequency of detections above the cleanup goals. None of the sediment or surface water at the Soldier Creek Sediment and Surface Water Operable Unit have contaminant concentrations exceeding these cleanup goals (1E-04 cleanup level).

The general cleanup level for PCBs in soil in an unrestricted access area is 10 ppm and in a restricted access area is 25 ppm. Although Tinker AFB could be classified as a restricted access area, the sample results were less than the criterion for an unrestricted access area (i.e., 10 ppm). Because the concentrations of PCB-1254 are below the general cleanup levels for an unrestricted access area, including PCBs as a sampling parameter within the selected alternative would be an adequate means of protecting human health and the environment. The general cleanup level for PCBs in sediment, if found, would be determined by an ecological risk assessment considering food chain effects.

6.5.6 *Conclusion*

None of the sediment or surface water contaminants detected in Soldier Creek during Phase I and II of the RI were detected at concentrations that exceeded the allowable carcinogenic risk range (1E-04 to 1E-06) or the noncarcinogenic HI of 1.0.

Because concentrations of several organic and inorganics were detected at background sampling locations, a "background" cancer risk is present for Soldier Creek sediment and surface water. However, because the values do not exceed the

1E-06 cancer risk level, the sediment and surface water do not present a threat to human health or the environment.

Actual or threatened migration of hazardous substances from the Soldier Creek Sediment and Surface Water Operable Unit, if not addressed by implementing the response action selected in this ROD, may potentially present an endangerment to public health, welfare, or the environment. The proposed response action will insure that any migration of contaminants from the operable unit at concentrations exceeding the risk-based cleanup levels established by EPA will be addressed through remedial action.

7.0 DESCRIPTION OF ALTERNATIVES

The six sediment and surface water (SSW) alternatives that were evaluated in detail in the FS report are described below. This discussion identifies engineering and treatment components, institutional controls, quantities of waste handled, implementation requirements, risk reduction, the estimated implementation time frame, and the primary applicable or relevant and appropriate requirements (ARARs) associated with each option. A detailed discussion of the alternatives is found in the FS report, which is part of the Administrative Record file.

Inherently, the removal, containment, or treatment of site media would offer the greatest protection to human health and the environment; however, the action alternatives that disturb the creek's environment could damage the aquatic ecosystem in Soldier Creek. Based on the qualitative environmental assessment conducted as a part of the baseline risk assessment and because the concentrations of the sediment and surface water COCs are not above the risk-based levels, an unacceptable risk to human health and the environment from site media in its existing condition does not exist.

7.1 SSW Alternative 1--No Action

- Capital Cost: Not Applicable.
- O&M Cost: $15,000 every five years.
- Present Worth: $11,700.
- Implementation Time: Not Applicable.

It is a requirement of the NCP and CERCLA to consider the no action alternative. The no action alternative would not involve any remedial actions or monitoring to indicate contaminant migration, and the operable unit would remain in its present condition. This alternative is the baseline alternative against which the effectiveness of the other alternatives is compared. A statutory five-year review of the operable unit would be conducted to determine if remedial actions need to be implemented. If remediation or monitoring are not conducted at the operable unit, it would be difficult to determine if contaminant migration occurred resulting in unacceptable public health risks. This alternative is not favored by Tinker AFB, EPA, or OSDH because it does not ensure the overall protection of human health and the environment; compliance with ARARs; long-term or short-term effectiveness; or the reduction of the toxicity, mobility, or volume of contaminated media. No reduction in the risk associated with site media would result from implementing this alternative; however, an unacceptable risk does not exist for the operable unit in its present condition.

7.2 SSW Alternative 2--Limited Action

- Capital Cost: Not Applicable.
- O&M Cost: $175,800 (years 1 and 2); $84,100 (years 3-5).
- Present Worth: $534,800.
- Implementation Time: Five Years (minimum).

This alternative would consist of implementing a five-year environmental monitoring program of Soldier Creek sediment and surface water. Sediment and surface water samples would be collected along East and West Soldier Creeks. Sampling would be conducted on a quarterly basis during the first two years of monitoring and semiannually during the last three years of monitoring. An ecological investigation of Soldier Creek sediment and surface water would also be conducted as a part of the environmental monitoring program to fully determine the effects of contaminant concentrations on the biological environment of the creek. The investigative activities of the monitoring program would be used to determine if a risk to human health or the environment develops at the operable unit.

Statutorily required five-year reviews would be conducted to ensure that no unacceptable exposures occur as specified in the NCP. If an unacceptable exposure develops at the operable unit, one of the other alternatives for remediation would be implemented at the operable unit.

The selected remedy would be implemented to comply with the federal and state action-specific ARARs for the operable unit. These ARARs include the following:

- Resource Conservation and Recovery Act (RCRA).
  - Hazardous Waste Management Systems General (Part 260).
  - Identification and Listing of Hazardous Waste (Part 261).
  - Standards Applicable to the Generators of Hazardous Waste (Part 262).
  - Standards Applicable to Transporters of Hazardous Waste (Part 263).
  - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Part 264).
  - Land Disposal Restrictions (Part 268).
  - Hazardous Waste Permit Program (Part 270).
- Hazardous Materials Transportation Act.
- Oklahoma Controlled Industrial Waste Disposal Act.
- Oklahoma Pollution Control Coordinating Act of 1968.
- Occupational Safety and Health Act (OSHA).

The contaminant-specific ARARs for the operable unit include the following:

- Risk-Based Cleanup Levels.
- RCRA--Identification and Listing of Hazardous Waste (Part 261).
- Oklahoma Water Quality Standards (WQS).
- Ambient Water Quality Criteria (AWQC).

Several surface water constituents exceeded the Oklahoma WQS and the AWQC during Phases I and II of the RI. However, sediment and surface water monitoring would be adequate to determine if an unacceptable risk develops at the operable unit and if the surface water constituents continue to exceed the Oklahoma WQS and the AWQC. Currently, there are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit. The location-specific ARARs would be reviewed throughout the remedial process and the status changed if data indicate a potential problem.

The estimated implementation time of this alternative is five years. No reduction in the risk associated with site media would result from implementing this alternative; however, an unacceptable risk does not exist for the operable unit in its present condition. A detailed description of this alternative, the selected remedy, is presented in Section 9.0.

7.3 SSW Alternative 3--Capping

- Capital Cost: $1,985,200.
- O&M Cost: $48,100.
- Present Worth: $2,193,400.
- Implementation Time: Nine months.

SSW Alternative 3 would involve the construction of a concrete-lined channel over on-base portions of East and West Soldier Creeks to minimize contaminant migration between the sediment, surface water, and groundwater at the operable unit. Surface water would be removed from Soldier Creek before the channel was constructed.

Temporary berms and pumps would be used to capture the surface water. The water would be transferred to a mobile, on-base treatment system for treatment. Treatment residuals would be disposed of as hazardous waste. After meeting the discharge standards, the treated surface water could be discharged to Soldier Creek downstream of the construction area or put to beneficial use at the Base. The discharge standards would be the Oklahoma WQS. Approximately 655,000 gallons of surface water would be treated during construction of the concrete-lined channel.

After completion of the concrete-lined channel and restoration of Soldier Creek to its original flow path, Soldier Creek surface water would be periodically monitored to determine the effectiveness of the capping system. Surface water monitoring would be conducted on an annual basis for a five-year period in the areas where the channel was constructed. Sediment and surface water monitoring would be performed at off-base locations. The final selection of these sampling locations would be agreed upon by Tinker AFB, the EPA, and the OSDH, and would be made during remedial design. The results of the monitoring program would also be reviewed to

determine potential interrelationships between sediment, surface water, and groundwater constituents.

This action-specific ARARs for the operable unit include the following:

- RCRA.
  - Criteria for the Classification of Solid Waste Disposal and Facilities and Practices (Part 257).
  - Hazardous Waste Management Systems General (Part 260).
  - Identification and Listing of Hazardous Waste (Part 261).
  - Standards Applicable to the Generators of Hazardous Waste (Part 263).
  - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Part 264).
  - Land Disposal Restrictions (LDRs) (Part 268).
  - Hazardous Waste Permit Program (Part 270).
- Hazardous Materials Transportation Act.
- Oklahoma Controlled Industrial Waste Disposal Act.
- Clean Water Act--National Pollutant Discharge Elimination System.
- Oklahoma Water Pollution Control Laws.
- Oklahoma Pollution control Coordinating Act of 1968.
- Clean Air Act National Ambient Air Quality Standards (NAAQS).
- Oklahoma Clean Air Act.
- OSHA.

The following are the federal and state contaminant-specific ARARs that pertain to SSW Alternative 3:

- Oklahoma Water Quality Standards.
- Risk-based Cleanup Levels.
- RCRA (Parts 261 and 268).
- Oklahoma Controlled Industrial Waste Disposal Act.
- Clean Air Act - NAAQS; Regulations on National Emission Standards for Hazardous Air Pollutants.
- Oklahoma Clean Air Act/Oklahoma Air Pollution Regulations.
- EPA Designation, Reportable Quantities, and Notification.

This alternative would meet all of the state and federal contaminant-specific ARARs and would be implemented in a manner that would not cause the action-specific ARARs to be violated. There are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit. The location-specific ARARs would be reviewed throughout the remedial process and the status changed if data indicate a potential problem.

The estimated implementation time of this alternative is nine months. Capping the on-base portions of Soldier Creek would lower the risk associated with operable unit

media; however, an unacceptable risk does not exist for the operable unit in its present condition.

7.4 SSW Alternative 4--Sediment Excavation and Off-Base Landfill Disposal

- Capital Cost: $2,542,300.
- O&M Cost: $47,600.
- Present Worth: $2,748,400.
- Implementation Time: Nine months.

SSW Alternative 4 would involve the excavation of sediment in on-base portions of East and West Soldier Creeks. Excavated sediment would be transported to an off-base RCRA hazardous waste landfill for disposal.

Surface water would be removed from Soldier Creek before sediment excavation. The water would be removed and treated as described under the capping alternative. Approximately 530,000 gallons of surface water would require treatment during alternative implementation. Approximately 5,630 cubic yards of sediment would be excavated from East and West Soldier Creeks. Soldier Creek sediment and surface water would be monitored annually for a five-year period to determine the effectiveness of the remedial action. Samples would be collected and analyzed, and a five-year review would be performed, as described under the capping alternative.

The contaminant-specific and action-specific ARARs would be the same as for SSW Alternative 3. Compliance with the LDRs should be achieved in the sediment without treatment because of the low concentrations of contaminants in the medium. After treatment, the surface water treatment residuals should not exceed the LDR requirements. If the LDR levels were exceeded, the sediment and treatment residuals would undergo further treatment before disposal. This alternative would meet all of the state and federal contaminant-specific ARARs and would be implemented in a manner that would not cause the action-specific ARARs to be violated. There are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit. The location-specific ARARs would be reviewed throughout the remedial process and the status changed if data indicate a potential problem.

The estimated implementation time of this alternative is nine months. Removal of sediment from the on-base portions of Soldier Creek would reduce or eliminate the risk associated with site media; however, an unacceptable risk does not exist for the operable unit in its present condition.

7.5 SSW Alternative 5--Sediment Excavation, Stabilization, and Off-Base Landfill Disposal

- Capital Cost: $5,708,600.
- O&M Cost: $47,600.
- Present Worth: $5,914,700.
- Implementation Time: Ten months.

SSW Alternative 5 would be the same as SSW Alternative 4 except that under this alternative, the sediment would be stabilized before it is transported to an off-base RCRA hazardous waste landfill for disposal.

The stabilization process consists of mixing the sediment with water and compounds that immobilize the contaminants in the sediment matrix. A treatability study would be conducted before the remedial action is implemented to determine operational parameters. A treatment and curing area and an area for stockpiling reagents and contaminated sediment would be required to implement this alternative. Samples of the cured, stabilized mass would undergo tests to evaluate the long-term stability of the material. The stabilization process would increase the volume approximately 5 to 60 percent, depending upon the additives and amount of water used. For estimating the cost of this alternative, it was assumed that the stabilization process would increase the excavated sediment volume by 20 percent.

The contaminant-specific and action-specific ARARs would be the same as for SSW Alternative 3. This alternative would meet all of the state and federal contaminant-specific ARARs and would be implemented in a manner that would not cause the action-specific ARARs to be violated. There are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit. The location-specific ARARs would be reviewed throughout the remedial process and the status changed if data indicate a potential problem.

The estimated implementation time of this alternative is ten months. Removal of sediment from the on-base portions of Soldier Creek would reduce or eliminate the risk associated with site media; however, an unacceptable risk does not exist for the operable unit in its present condition.

7.6 SSW Alternative 6--Sediment Excavation and Soil Washing

- Capital Cost: $6,371,600.
- O&M Cost: $47,600.
- Present Worth: $6,577,700.
- Implementation Time: Fourteen months.

SSW Alternative 6 would be the same as SSW Alternative 4 except that soil washing would be used to remediate the excavated sediment before it is transported to an off-base RCRA hazardous waste landfill for disposal.

The soil washing process involves removing contaminants from the sediment particles in a mobile treatment unit using water, surfactants, and other additives, if necessary. A treatability study would be performed before implementation to determine the effectiveness of the soil washing process on the sediment and to determine any additives required to treat the sediment. A staging area would be required for treatment. The treatment residuals would be disposed of at an off-base RCRA hazardous waste landfill. Treatment process water remaining after the soil wash process is completed would be treated in the mobile, on-base treatment system. Soil washing is an innovative treatment technology whose reliability is not entirely proven.

The contaminant-specific and action-specific ARARs would be the same as for SSW Alternative 3. This alternative would meet all of the state and federal contaminant-specific ARARs and would be implemented in a manner that would not cause the action-specific ARARs to be violated. There are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit. The location-specific ARARs would be reviewed throughout the remedial process and the status changed if data indicate a potential problem.

The estimated implementation time of this alternative is fourteen months. Removal of sediment from the on-base portions of Soldier Creek would reduce or eliminate the risk associated with site media; however, an unacceptable risk does not exist for the operable unit in its present condition.

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The NCP has established nine evaluation criteria to address CERCLA statutory requirements and the technical, cost, and institutional considerations associated with a remedial alternative that the EPA has determined appropriate. The evaluation criteria are the basis for conducting the detailed alternative analysis in the FS report and for selecting the final remedy for the operable unit. The results of comparing the preferred alternative and the other remedial alternatives with the following nine evaluation criteria are addressed in this section:

- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, or volume through treatment.
- Short-term effectiveness.
- Implementability.
- Cost.
- State acceptance.
- Community acceptance.

The first two criteria are threshold criteria. These criteria must be met for an alternative to be considered a remedy for a operable unit. The next five criteria are considered balancing criteria. Tradeoffs are made among alternatives with respect to these criteria. The last two criteria are considered modifying criteria and are used to identify the preferred alternative after the public comment period.

8.1 Overall Protection of Human Health and Environment

The selected remedy for the operable unit will not involve the remediation of Soldier Creek sediment and surface water as is proposed under SSW Alternatives 3, 4, 5, and 6. Inherently, the removal, containment, or treatment of site media offers the greatest protection to human health and the environment; however, based on the qualitative environmental assessment conducted as a part of the baseline risk assessment and because the concentrations of the sediment and surface water chemicals of concern are not above the risk-based cleanup goals established by EPA, an unacceptable risk to human health and the environment from site media in its present condition does not exist. Therefore, remediation of this media is not necessary at this time. The selected remedy will provide monitoring (quarterly for the first two years and semi-annually for the next three years of monitoring) of site media to determine if an unacceptable sediment or surface water risk develops at the operable unit and, therefore, will be more protective of human health and the environment than SSW Alternative 1, the no action alternative. In addition, a quantitative environmental assessment will be conducted to fully determine the affect of site contaminants on the Soldier Creek biological environment. The short-term

effects to the public residing in the vicinity of the operable unit, Base employees, the sediment and surface water sampling team, and the environment from implementing the preferred alternative will be insignificant compared with the potential short-term impacts associated with implementing an intrusive remedy at the operable unit.

8.2 Compliance with ARARs

Several surface water constituents exceeded the Oklahoma WQS and the AWQC during Phases I and II of the RI. However, sediment and surface water monitoring will be adequate to determine if an unacceptable risk develops at the operable unit and if the surface water constituents continue to exceed the Oklahoma WQS and the AWQC. Sediment and surface water monitoring will be adequate to determine if a significant risk develops at the operable unit. SSW Alternative 2 will be implemented to comply with all of the federal and state action-specific ARARs for the operable unit. There are no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable unit; however, these ARARs will be reviewed throughout the remedial process and the status changed if necessary. All of the alternatives involving intrusive remediation would comply with the contaminant-specific ARARs and would be conducted to comply with their associated action-specific ARARs. The LDRs would be applicable to any alternative that involved the treatment of sediment or surface water (SSW Alternatives 3, 4, 5, and 6) because listed wastes were found at the Soldier Creek Sediment and Surface Water Operable Unit, or if treatment residuals exhibit any of the RCRA characteristics. A listed waste is a waste that is hazardous because it is named on one of three lists developed by EPA (non-specific source wastes, specific source wastes, and commercial chemical products). A characteristic waste is one that exhibits the properties of ignitability, corrosivity, reactivity, or toxicity as defined by EPA, and is therefore considered a hazardous waste. The treatment residuals should not exceed the LDR requirements; however, if the residuals do exceed the LDRs, the residuals would require further treatment before land disposal.

8.3 Long-Term Effectiveness and Permanence

There will be no long-term unacceptable risk to human health or the environment from Soldier Creek sediment or surface water from implementing the selected remedy as long as the concentrations of the chemicals of concern in the operable unit media do not exceed the risk-based cleanup levels. The risk to the environment will be fully evaluated by conducting an ecological investigation of Soldier Creek. SSW Alternative 2 will provide long-term effectiveness by detecting any increases in contaminant concentration and risk. Ideally, the alternatives that involve the containment or treatment of sediment and the treatment of surface water (SSW Alternatives 3, 4, 5, and 6) afford a greater amount of long-term effectiveness and permanence; however, based on the current conditions in Soldier Creek, this is not required for the sediment and surface water in the stream. SSW Alternative 3, which involves the capping of on-base portions of Soldier Creek, would not be as

permanent as the other intrusive alternatives because sediment would not be removed from the creek and treated or disposed of. The selected remedy will be more protective of the public and the environment than the no action alternative because monitoring will indicate if a significant sediment or surface water risk develops at the operable unit and will determine the migration or persistence of the chemicals of concern in these media. Changes in the condition of Soldier Creek sediment and surface water could not be determined under the no action alternative because the statutory five-year review does not include sampling of operable unit media. If a risk to human health and the environment develops in the operable unit media during the remediation period, additional remedial action may be necessary.

8.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Variable reductions in the toxicity, mobility, and volume of operable unit media would be achieved by implementing SSW Alternatives 5 or 6. The selected remedy does not involve any treatment methods to reduce the toxicity, mobility, or volume associated with the chemicals of concern detected in Soldier Creek sediment and surface water. Implementation of the no action alternative would not reduce the toxicity, mobility, or volume of operable unit media by treatment methods. However, because an immediate risk to human health or the environment is not posed by existing contaminant concentrations in the sediment or surface water, treatment of these media to meet the cleanup goals is not warranted.

8.5 Short-Term Effectiveness

No short-term risks would be associated with the no action alternative. SSW Alternative 2 will provide short-term effectiveness because there are currently no unacceptable risks associated with Soldier Creek sediment and surface water. The short-term risks associated with the selected remedy include exposure of the sampling team to operable unit media and the temporary disturbance of the Soldier Creek ecosystem during sampling. These impacts will be minimal because no immediate risk exists for the sediment and surface water and the proper sampling procedures will be followed. No impacts would be encountered by off-base residents living adjacent to the creek during implementation of SSW Alternative 2. The potential risks to the site workers, off-base residents, and the environment from implementing alternatives involving intrusive remediation activities (SSW Alternatives 3, 4, 5, and 6) would be greater than those for the preferred alternative. Cap construction and sediment excavation would alter the physical condition and the vegetation and wildlife in and along Soldier Creek. Site workers and off-base residents would be exposed to fugitive dust emissions and surface runoff may occur during implementation. These potential exposures would be minimized by compliance with OSHA requirements, by requiring workers to wear the appropriate personal protective equipment, and by implementing engineering controls such as using dust suppressants, constructing berms, and conducting air monitoring during remediation.

In conjunction with the FS report, an Environmental Assessment report addressing the effects of the proposed alternatives on human health and the environment was prepared. This report concluded that the impact to the environment from implementing an intrusive alternative at the operable unit would be great compared with the limited action alternative. The construction and excavation activities that are a part of these alternatives would severely damage or destroy the Soldier Creek ecosystem during implementation. Areas downstream of the Base may also be temporarily affected by alternative implementation. Remedial activities may alter the creek ecosystem in a manner that would not allow certain species to survive. However, over time, the ecosystem of the creek would eventually return. Through proper engineering controls, implementation of an intrusive remedial action would not have an adverse effect on the public or operable unit workers. The Environmental Assessment report summarizes the effects of each of the proposed alternatives in greater detail.

The alternatives involving intrusive activities would take approximately one year to construct. SSW Alternatives 2, 3, 4, 5, and 6 would involve monitoring activities to be implemented over a five-year period. After five years, a statutory review would be conducted to determine the success of the alternatives.

8.6 Implementability

The no action alternative would be the simplest alternative to implement because it only involves the completion of a five-year review at the operable unit. The selected remedy is implementable using conventional methods that are established and reliable. The specialists, equipment, and services required to implement the selected alternative are readily available. The alternative is much simpler to implement than SSW Alternatives 3, 4, 5, and 6 because of the activities involved during implementation. Even though the majority of the techniques to be used in the intrusive alternatives are conventional and readily available, these alternatives would involve a great deal more coordination and would be labor-intensive to implement.

8.7 Cost

The present worth cost of the no action alternative is approximately $12,000. The present worth cost of the selected remedy has the second lowest cost (approximately $535,000) of all of the proposed alternatives. The approximate present worth costs of SSW Alternatives 3, 4, 5, and 6 are $2.2 million, $2.7 million, $5.9 million, and $6.6 million, respectively.

8.8 State Acceptance

The OSDH concurs with the selected remedy for the sediment and surface water media at the Soldier Creek Sediment and Surface Water Operable Unit. Acceptance of the limited action remedy, in letter form, when received from OSDH will be included in the ROD as Appendix B.

8.9 Community Acceptance

Community acceptance is specifically addressed in the Responsiveness Summary which is presented in Appendix A. The Responsiveness Summary provides a thorough review of the public comments on the RI/FS, baseline risk assessment, and Proposed Plan, and Tinker AFB's responses to the comments. The individuals who made verbal comments at the public meeting did not express strong support for the selected remedy; however, no written comments were received during the public comment period.

9.0 SELECTED REMEDY

Based on the quantitative and qualitative results of the baseline risk assessment, it has been determined that the sediment and surface water contamination at the Soldier Creek Sediment and Surface Water Operable Unit does not present a significant threat to human health or the environment and, therefore, the only response actions at this time are those specified in SSW Alternative 2, the limited action alternative. Soldier Creek sediment and surface water do not pose a risk to human health and the environment based on the baseline risk assessment and the qualitative environmental assessment conducted as a part of the baseline risk assessment, and because remedial action objectives are met without implementing an intrusive response action at the operable unit. The remedial action objectives for the operable unit are as follows:

- Prevent the ingestion of or direct contact with Soldier Creek sediment and surface water with contaminant concentrations greater than the final remediation goals.
- Prevent the migration of contaminants, with concentrations greater than the final remediation goals, to the groundwater that would result in groundwater contamination. However, existing or potential groundwater contamination will be addressed under the Soldier Creek Groundwater Operable Unit.

Contaminant concentrations in these media do not exceed the remediation goals for the operable unit. These goals are based on the risk calculations conducted as part of the baseline risk assessment and are presented in Table 6-3 (pages 6-11 and 6-12). The investigative activities of the monitoring program and the ecological investigation will be used to determine if a risk to human health develops and to quantitatively evaluate the environmental risk, if any, that exists at the operable unit. The environmental assessment conducted as a part of the baseline risk assessment was only qualitative in nature and cannot be used to fully determine the ecological risk.

The selected remedy consists of implementing a five-year environmental monitoring program of Soldier Creek sediment and surface water. Sediment and surface water samples will be collected along East and West Soldier Creeks. The final selection of these sampling locations will be agreed upon by Tinker AFB, OSDH, and EPA during remedial design.

Sampling will be conducted on a quarterly basis during the first two years of monitoring and semiannually during the last three years of monitoring. The sediment and surface water samples will be analyzed for contaminants of concern. Volumetric stream flow and the pH, conductivity, and dissolved oxygen content of the surface water will be measured in the field at the time of the surface water sample collection.

A workplan for the monitoring program will be developed during remedial design. The workplan will be approved by all parties of the FFA, and will be the final authority for tasks to be completed under the selected remedy. The workplan will accomplish the following tasks, at a minimum:

- Establish sampling boundaries along East and West Soldier Creeks.
- Divide the stream into sampling segments based on visual inspection, stream morphology, flow characteristics, and stream use.
- Determine sampling locations by dividing each sampling segment into quarters. During each quarterly sampling event, a different quarter of each sampling segment will be sampled. This procedure will allow the samples collected over a year of monitoring to be more representative of the stream.
- Determine contaminants of concern.
- Determine and describe sediment and surface water sampling methods.
- Determine and describe the extent of data analysis to be conducted.
- Define response if a sample concentration exceeds an unacceptable exposure. This will likely involve resampling, identifying the source if possible, and taking the appropriate remedial action if necessary.
- Provide for modifications to the monitoring program, such as expanding the sampling regime and boundaries if necessary.

The workplan will include all of the tasks to be performed under the monitoring program and during the ecological investigation.

The ecological investigation of Soldier Creek sediment and surface water conducted as a part of the environmental monitoring program will be used to determine the effects of existing contaminant concentrations on the biological environment of the creek. An ecological assessment of the aquatic plants, aquatic invertebrates, and fish that inhabit Soldier Creek will be performed. The assessment will include a biological survey of both on-base and off-base portions of Soldier Creek to determine the number, identity, and approximate population size of the species living within the Soldier Creek Sediment and Surface Water Operable Unit area. Aquatic plants will be identified in the field, fish will be sampled with a seine and identified in the field, and benthic samples will be collected and analyzed in a laboratory to identify aquatic invertebrates. The investigation will include all living organisms other than humans and domesticated animals that may come into contact with Soldier Creek sediment or surface water. The assessment will also be quantitative and include an exposure assessment to identify potential contaminant pathways, a toxicity assessment to identify contaminants of concern to aquatic organisms, and a risk characterization to quantify the overall potential or actual effects of the contaminants on the plants and animals that inhabit Soldier Creek. The ecological assessment will also address any existing or potential risk to the environment from PCBs.

Information from the Building 3001 groundwater monitoring program at Tinker AFB and from the investigation of the Soldier Creek Groundwater Operable Unit will be reviewed yearly to monitor the condition of the groundwater and to note potential interrelationships between sediment, surface water, and groundwater constituents. A yearly monitoring report will be completed to summarize the sediment, surface water, and groundwater analytical results and to compare the results with previously obtained data. The yearly monitoring reports will be placed in the Soldier Creek Administrative Record. The monitoring report will also be added to the new Groundwater Operable Unit Administrative Record.

During the five-year review, the results of the annual reports and other information, including operable unit conditions, will be evaluated. If, upon completion of the five-year review, the Air Force, EPA, and OSDH determine that the Soldier Creek Sediment and Surface Water Operable Unit does not present a potential threat to human health or the environment, the sediment and surface water monitoring will be terminated. Statutorily required five-year reviews will be conducted to ensure that no unacceptable exposures occur as specified in the NCP.

As a part of the annual monitoring report, the quarterly and semiannual monitoring results will be evaluated and compared with existing data and applied to criteria to determine if any unacceptable exposures occur. The following criteria will be used to designate an unacceptable exposure:

- Contaminant concentrations in sediment or surface water exceeding health based levels based on an excess lifetime cancer risk of 1E-04. Contaminant concentrations detected within the 1E-04 to 1E-06 range may potentially indicate an unacceptable exposure and will be evaluated to determine if the exposure was unacceptable and remediation, therefore, necessary.

- Contaminant concentrations in sediment or surface water with noncarcinogenic HIs greater than 1.0.

- Contaminant concentrations in sediment or surface water that present an unacceptable ecological risk.

If contaminant concentrations increase to levels where there exists an unacceptable exposure, then another alternative for remediation will be evaluated and, if appropriate, will be implemented upon consensus by the EPA, OSDH, and Tinker AFB. If another treatment alternative is necessary, either an explanation of significant difference or an amendment to the ROD pursuant to the NCP will be issued.

The detailed summary of the operation and maintenance (O&M) costs associated with the implementation of the selected remedy is presented in Table 9-1 (page 9-5). There are no capital costs associated with this alternative. The O&M costs associated with implementing this alternative consist of the sampling and analysis of Soldier Creek sediment and surface water, an ecological assessment, disposal of sampling-derived waste, review of the Base-wide groundwater results for wells in the vicinity of the stream, preparation of an annual monitoring report, and the five-year review. The cost of the five-year review does not involve a site visit. The annual cost for years 1 and 2 is estimated to be $175,800. The annual cost for years 3 through 5 is estimated to be $84,100. The total present worth of the selected remedy is estimated to be $534,800.

TABLE 9-1
SELECTED REMEDY COST ESTIMATE
TINKER AFB - SOLDIER CREEK
RECORD OF DECISION

ALTERNATIVE COMPONENTS	QUANTITY	UNIT	UNIT COST	COST (1)
Environmental Sample Collection (2)				
Year 1-2	4	EVENT	22,000	$88,000
Year 3-5	2	EVENT	22,000	$44,000
Surface Water Analysis (3)				
Year 1-2	72	SAMPLE	395	$28,400
Year 3-5	36	SAMPLE	395	$14,200
Sediment Analysis (3)				
Year 1-2	72	SAMPLE	375	$27,000
Year 3-5	36	SAMPLE	375	$13,500
Ecological Assessment (4)	1	EVENT	20,000	$20,000
Environmental Monitoring Program Report				
Year 1-5	1	DELIVERABLE	10,000	$10,000
Five-Year Review (5)				
Year 1-5 at 5 Percent Discount Rate	1	EACH	13,000	$2,400
CAPITAL COST				$0
O&M COST SUMMARY				
Year 1-2				$175,800
Year 3-5				$84,100
TOTAL PRESENT WORTH				
Assuming a 5 Percent Discount Rate for 5 Years				$534,800

(1) All costs rounded to the nearest hundred.
(2) Sample collection is assumed to require 3 people over a period of 7 days. Sampling-derived waste would be disposed of at a nonhazardous waste landfill.
(3) Analyses consist of contaminants of concern.
(4) Ecological assessment is assumed to require 2 people over a period of 6 days for the biological field survey and 1 person over a period of 2 weeks to prepare an exposure assessment, a toxicity assessment, and a risk characterization.
(5) The future cost of the review is converted to an annual cost. A site visit would not be required as part of the five-year review.

10.0 STATUTORY DETERMINATIONS

Tinker AFB's primary responsibility at the Soldier Creek Sediment and Surface Water Operable Unit is to undertake a remedial action that achieves adequate protection of human health and the environment. In addition, the selected remedy must satisfy the statutory requirements of Section 121(b) of CERCLA. This section states that the selected remedy must accomplish the following:

- Be protective of human health and the environment.
- Comply with federal and state ARARs upon completion of alternative or attain a waiver.
- Be cost-effective.
- Utilize permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable and satisfy the statutory preference for treatment as a principle element, or justify not meeting the preference.

10.1 Protection of Human Health and Environment

The selected remedy is protective of human health and the environment because monitoring of the concentrations of the chemicals of concern in Soldier Creek sediment and surface water will be conducted and an ecological investigation will be performed. Continued monitoring will determine if a human health risk develops from these media at the operable unit. Implementation of the selected remedy does not pose any unacceptable short-term risks or cross-media impacts.

Because carcinogenic risk levels are within the acceptable risk range (1E-04 to 1E-06) and the HIs for noncarcinogens are less than 1.0, the sediment and surface water contamination at the Soldier Creek Sediment and Surface Water Operable Unit does not present a significant threat to human health. Based on the qualitative environmental assessment conducted as a part of the baseline risk assessment, a significant threat to the environment does not exist. Therefore, the only response action required at this time is that specified in the selected remedy. The continued monitoring of Soldier Creek sediment and surface water at on-base and off-base sampling locations will be adequate to address operable unit contamination because the concentrations of the sediment and surface water COCs do not exceed the remediation goals (risk-based cleanup levels) established for the operable unit. The ecological assessment to be conducted will determine the effects of contaminant concentrations on the biological environment of Soldier Creek. Yearly and at the time of the five-year review, the results of the monitoring program will be evaluated to determine if a remedial action needs to be implemented or additional monitoring needs to be conducted at the operable unit.

10.2 Compliance with ARARs

The selected remedy complies with the federal and state action-specific ARARs for the operable unit. These ARARs include the following:

- RCRA.
  - Hazardous Waste Management Systems General (Part 260).
  - Identification and Listing of Hazardous Waste (Part 261).
  - Standards Applicable to the Generators of Hazardous Waste (Part 262).
  - Standards Applicable to Transporters of Hazardous Waste (Part 263).
  - Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities (Part 264).
  - Land Disposal Restrictions (Part 268).
  - Hazardous Waste Permit Program (Part 270).
- Hazardous Materials Transportation Act.
- Oklahoma Controlled Industrial Waste Disposal Act.
- Oklahoma Pollution Control Coordinating Act of 1968.
- OSHA.

The contaminant-specific ARARs for the operable unit include the following:

- Risk-based Cleanup Levels.
- RCRA--Identification and Listing of Hazardous Waste (Part 261).
- Oklahoma WQS.
- AWQC.

Several surface water constituents exceeded the Oklahoma WQS and the AWQC during Phases I and II of the RI. However, sediment and surface water monitoring will be adequate to determine if an unacceptable risk develops at the operable unit and if the surface water constituents continue to exceed the Oklahoma WQS and the AWQC. There are currently no location-specific ARARs for the Soldier Creek Sediment and Surface Water Operable Unit; however, these ARARs will be reevaluated throughout the remedial process and the status changed if necessary.

10.3 Cost-Effectiveness

The selected remedy is cost effective because it has been determined to provide overall effectiveness proportional to its cost. The net present value of the remedy is approximately $535,000. Because the baseline risk assessment determined that the Soldier Creek Sediment and Surface Water Operable Unit in its current condition does not pose a significant threat to human health and the environment, an intrusive response action is not necessary at this time. Therefore, the selected remedy is the least costly of remedies that are sufficiently protective of human health and the environment.

10.4 Utilization of Permanent Solutions and Alternative Treatments

The selected remedy utilizes permanent solutions and treatment technologies to the maximum extent practicable. However, based on the results of the baseline risk assessment, meeting this criterion does not currently require the involvement of permanent treatment solutions. Because remediation is not necessary at the Soldier Creek Sediment and Surface Water Operable Unit, the selected remedy offers long-term effectiveness and permanence in the protection of human health and the environment. Although no reduction of toxicity, mobility, or volume of site contaminants through treatment will occur as a result of implementing the selected remedy, the proposed monitoring program will provide short-term effectiveness. The potential short-term risks to site workers, the community, and the Soldier Creek ecosystem during implementation are minimal compared to the risks associated with an intrusive remedy. The selected remedy is easily implementable, and the cost is low compared to the costs of implementing an intrusive remedy.

If, over the five-year period before the statutory review, monitoring indicates an increase in contaminant concentrations to the point where the sediment or surface water consistently exceeds the risk-based cleanup levels, implementation of another site remedy will be evaluated. If one of the other treatment alternatives is necessary at the operable unit, either an explanation of significant differences or an amendment to the ROD pursuant to the NCP will be issued.

10.5 Preference for Treatment

CERCLA provides a statutory preference for remedies that use treatment as a principle element of a remedy. However, as it has been determined that treatment is not necessary, it will not be used at this operable unit. Treatment of Soldier Creek sediment and surface water is not practicable because the concentrations of site contaminants of concern do not exceed the acceptable range of carcinogenic risk values and noncarcinogenic HI values developed in the baseline risk assessment. Because the values are not exceeded, there is no basis on which to calculate areas to be remediated.

11.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for the Soldier Creek Operable Unit was released for public comment on April 15, 1993. The public comment period ended on June 17, 1993. It identified the preferred alternative to be the limited action alternative, which involves continued monitoring of Soldier Creek sediment and surface water and an ecological assessment to be conducted at the operable unit. No significant changes will be made to the proposed remedy as a result of the public comment period.

APPENDIX A

RESPONSIVENESS SUMMARY

A.1 INTRODUCTION

The purpose of this responsiveness summary is to present the significant comments received during the public comment period on the RI/FS and the Proposed Plan and to respond to those comments and how they affected the ROD.

The Proposed Plan and the Administrative Record file were made available to the public in April 1993 in the Midwest City Public Library, Tinker AFB, the OSDH (as of July 1, 1993, this division of OSDH became part of the new Department of Environmental Quality) offices in Oklahoma City, Oklahoma, and the EPA Region 6 offices in Dallas, Texas. The public comment period was scheduled to be open between April 16, 1993 and May 17, 1993. A public meeting was scheduled and held on April 27, 1993. Both the public comment period and the public meeting were initially announced to the public in the *Daily Oklahoman*, which is a large local newspaper of general circulation, on April 16, 1993. Another newspaper announcement was placed in the community section of the *Daily Oklahoman* on April 26, 1993. A press conference was also held the same day to announce the public meeting. At the public meeting, a request was received to extend the public comment period. Accordingly, the public comment period was extended to June 17, 1993. A notice was placed in the *Daily Oklahoma* for three days notifying the public of this extension.

A.2 SOURCE OF COMMENTS

Public comments were received verbally during the public meeting. No written comments were received during the public comment period.

A copy of the transcript of the public meeting is available in the Administrative Record file. The content of the verbal comments and Tinker AFB's comments are contained in this summary.

A.3 SUMMARY OF COMMENTS FROM THE PUBLIC HEARING AND TINKER AFB'S RESPONSE

The following is a summary of the comments received during the public meeting. After each comment is a summary of the Tinker AFB response provided at the meeting. The comments and responses are presented in the order that they were addressed during the public meeting.

Commentator 1

1. Comment:
   Is Tinker AFB aware of the Good Neighbor Agreement made between Tinker AFB and the Citizens for a Clean Environment a few years back? A free exchange of information and data to the group is to be provided upon request, as long as the information is not classified. Approximately one year ago, I requested the field study of risk assessment data and I was refused on the

grounds that it was raw data and it had not been compiled and extrapolated. I feel that this is potentially a violation of the Good Neighbor Agreement.

Tinker AFB's Response:
Tinker AFB is aware of the Good Neighbor Agreement between the Base and the Citizens for a Clean Environment. To Tinker AFB's knowledge, everything asked for by the group has been provided, from community awareness to the chemicals on the Base. We have given your organization tours of the Base. At the time of the request for the raw data, nothing was available to give the group. This data is now available in the Administrative Record file, which is available at the Midwest City Public Library.

2. Comment:
Why did the group not receive notice of the public comment period before April 16, 1993? Tinker AFB may have fulfilled their legal obligation by placing the notice in the back of the *Journal Record*, but if Tinker AFB knew that there was an interested group that represented a great number of people, why was the group not notified earlier? I had made earlier inquiries before as to when this information would be made available but I was never given notice that it is now available to the public. Tinker AFB knows of the group's existence and has our mailing address and phone number.

Tinker AFB's Response:
Tinker AFB had no intention of slighting any citizen or group on the availability of the Administrative Record file and the notice of the public comment period and meeting. The public notice was placed in the *Daily Oklahoman*; however, Tinker AFB has no control over where in the newspaper the notice is placed. Tinker AFB apologizes that your group took offense to the fact that the notice was not sent to you directly. A notice was also sent out to the mailing addresses. At that time, 30 days were remaining in the public comment period.

3. Comment:
I received a notice in the mail that was postmarked April 23, 1993. I received it on April 24, 1993. This is quite a few days after the public comment period began. The citizens were slighted on the public comment period and the notice. It will take a while to look over this information to either agree with it or to identify opposing experts.

Tinker AFB's Response:
The information that you received on April 24, 1993 was the Fact Sheet.

4. Comment:
In the Soldier Creek investigation, was any consideration given to soil, groundwater, or air quality contamination in other areas that will impact the creek or was it looked at as a single entity?

Tinker AFB's Response:
The remedial investigation was specifically conducted on Soldier Creek sediment and surface water at on-base and off-base locations. The investigation focused on specific chemicals in the creek sediment and surface water to determine the nature and extent of contamination. Identification of the chemicals does not necessarily determine the source of the contamination. In addition to sediment and surface water data, the RI report summarizes groundwater data collected in the vicinity of Soldier Creek. A baseline risk assessment was prepared to address exposure to all three of these media. However, only the sediment and surface water were addressed in subsequent documents (FS, Proposed Plan, and ROD) because the groundwater data was not adequate to fully determine the horizontal and vertical extent of contamination and the hydrogeology in the area of Soldier Creek is complex. It was determined that the groundwater contamination could be more thoroughly and properly evaluated by conducting additional investigation and by establishing a Soldier Creek groundwater operable unit at the Tinker AFB Site. All of the aforementioned documents are available in the Administrative Record file.

5. Comment:
Was there any potential for backwash of contaminants from the main portions of Soldier Creek that originate on the Base into the "C" and "D" tributary segments of Soldier Creek used as background locations?

Tinker AFB's Response:
The background locations were selected far enough downstream of Tinker AFB and at distance from the confluence of the tributaries with the main portion of Soldier Creek to avoid a "backwashing" of contaminants from Tinker AFB into these tributaries. In addition, the background locations were placed on private property so as to avoid potential sources of off-base contamination.

6. Comment:
Were any contaminants found in the area of segment M3?

Tinker AFB's Response:
Bis(2-ethylhexyl)phthalate (3 out of 4 samples) and barium (4 out of 4 samples) were detected in the 0-6 inch sediment sampling interval (Phase I of the RI). Chlorobenzene (one out of 8 samples), bis(2-ethylhexyl)phthalate (7 out of 8 samples), and barium (8 out of 8 samples) were detected in the 0-5 foot sediment sampling interval (Phase II of the RI). Chloroform (2 out of 4 samples); cyanide

(one out of 4 samples); and chromium, potassium, selenium, and sodium (4 out of 4 samples) were detected in the surface water (Phase I of the RI).

7. Comment:
Does Tinker AFB agree that Soldier Creek is a recharge site of the Garber-Wellington Aquifer?

Tinker AFB's Response:
Along the length and breadth of the stream, Soldier Creek is a recharge site. It is either recharged by the groundwater or recharges the groundwater along its length. In the immediate area surrounding Tinker AFB, preliminary data has indicated that the groundwater recharges the creek system, but the creek does not recharge the groundwater. Investigations are currently being conducted to more fully evaluate the interactions between Soldier Creek and the Garber-Wellington Aquifer. Flow measuring devices have been placed in the creek and the permeability of the creek sediment is being measured.

8. Comment:
For risk assessment exposures, did the sampling team go door to door in the neighborhood just south and northeast of 10th Street and interview any of the neighbors. Many of the children in this neighborhood play in the creek and catch crawfish. There are some fish large enough in the creek for the kids to catch and take home to eat. In addition, many metals are bioaccumulative.

Tinker AFB's Response:
Exposure scenarios used in the baseline risk assessment did not necessarily consider a specific individual but a type of receptor that may be exposed to the creek system. The exposure scenarios are independent of who lives along the creek because a risk is estimated for each individual segment. The risks were evaluated for more broad-based receptors (e.g., adult worker, child or adult playing in creek). The Agency for Toxic Substances and Disease Registry is the agency responsible for conducting door to door interviews and other types of inquiries of this nature. Such an assessment was conducted in May 1993.

It is correct that many metals bioaccumulate. The effect of such metals, if any, on the Soldier Creek ecosystem will be fully evaluated during the ecological investigation to be conducted as a part of the selected remedy.

9. Comment:
It was stated that some of the chemicals in one of the surface water grab samples exceeded the water standard. Were any of these samples collected during a period when Tinker AFB was in violation of its NPDES permit?

Tinker AFB's Response:
Phase I and II of the RI samples were not collected during a period of NPDES permit violation. However, on June 18, 1990, the discharges from the Base exceeded permit requirements for pH. On June 7, 1991, the discharges from the Base exceeded permit requirements for total suspended solids. Both of these permit violations occurred before the sediment and surface water was sampled.

10. Comment:
Water quality varies from day to day in Soldier Creek depending upon what is discharged from the Base. If a sample was taken on a day of minimal discharges as opposed to a day of discharges that resulted in permit violations, it would make a considerable difference in the concentrations of the sample collected, especially in making any kind of health risk assessment.

Tinker AFB's Response:
That is correct. For this reason, surface water samples were collected during two sampling events, Phase I (July 1990) and Phase II (June 1991) of the remedial investigation.

Commentator 2

11. Comment:
I would like to begin by going on the record asking for an extension of the public comment period. There has not been enough time allowed for anyone to study the situation adequately. I just received the notice yesterday, so I need more time to respond.

Tinker AFB's Response:
The public comment period has been extended until June 17, 1993.

12. Comment:
In regards to the recharge of the creek, I have done hydrogeological studies that show that the shallow aquifer of the alluvium recharges Soldier Creek and that Soldier Creek recharges the Garber-Wellington Aquifer. Therefore, I am concerned about this charge and recharge of the stream. It is known that the alluvium is contaminated with trichloroethene and chromium; therefore, it can be expected that these contaminants will enter the surface water and ultimately seep down. My concern is that during this particular study, the focus was on sediment and surface water. I assume that the reason you focused on these media was because it is the first pathway to human exposure. However, the selected remedy of a five-year study including groundwater and ecological studies, should already have been occurring before it got to this point. My concern is, with the recharge issue, it appears that you are chasing your tail in making a decision before going further into remediating the site.

Tinker AFB's Response:
In the answer to the previous question concerning recharge, it was not the intention to give an indication of where Tinker AFB is at in the overall investigation and study process at the Base, but to answer a direct question about recharge in the area of Soldier Creek.

Under CERCLA, as amended by SARA, there is a set procedure to follow in performing remedial investigations and feasibility studies. Tinker AFB is required by the EPA to follow these procedures. Perhaps things could be conducted to expedite the process, but the process that Tinker AFB executed to get to this point was explained during the public meeting presentation.

The groundwater associated with Soldier Creek is not going to be addressed in the five-year program of the selected remedy because not enough data exists to determine the horizontal and vertical extent of groundwater contamination and the hydrogeology in the area of Soldier Creek is complex. The groundwater will be addressed as a separate operable unit entitled the Soldier Creek Groundwater Operable Unit. The objective of the flow measuring devices installed in Soldier Creek was not to support the existing study (Soldier Creek Sediment and Surface Water Operable Unit), but to get a head start on the groundwater operable unit investigation.

13. Comment:
When can we expect results on the groundwater?

Tinker AFB's Response:
Tinker AFB actively monitors groundwater monitoring wells in the area of Soldier Creek as a part of the basewide groundwater monitoring program. In addition, Tinker AFB will be going through the same type of process in addressing the groundwater as it did to address the sediment and surface water. We will be developing a workplan and a sampling and analysis plan before beginning the actual investigation. These activities will begin within the next couple of months, as soon as a complete schedule is set.

14. Comment:
Was bioremediation considered as part of the plan?

Tinker AFB's Response:
Bioremediation was considered during the initial technology screening process conducted during the feasibility study and as presented in the FS Initial Screening of Alternatives Report.

15. Comment:
Why was bioremediation not included in this plan?

Tinker AFB's Response:
Bioremediation was not included for several reasons. First of all, both organic contaminants and metals are present in the sediment and surface water. Bioremediation is appropriate only for remediating organic contaminants that are biodegradable. In addition, some metals, such as chromium and cyanide, are toxic to the biological treatment process. Chlorinated organic compounds can also be toxic to the process at high concentrations. To effectively sustain biological treatment, a relatively high concentration of organic contamination must be present in the medium to be remediated. Biodegradable organic contaminants are present at low concentrations in Soldier Creek sediment and surface water.

16. Comment:
I would like to be on the record for asking that SSW Alternative 4 using bioremediation to protect public health and the environment in the area of Soldier Creek be implemented at the site. I would like Tinker AFB, OSDH, and the City of Midwest City to put up health warning signs along the creek warning children not to play there, not to eat the fish, and not to play with the aquatic life, in order to protect the health and safety of the residents of Midwest City.

Tinker AFB's Response:
The baseline risk assessment conducted for Soldier Creek sediment and surface water indicates that no unacceptable risk exists. Because the concentrations of contaminants in the sediment and surface water do not exceed values determined in the baseline risk assessment to be a threat to human health or the environment, it is impossible to determine the areas or volumes of media that would be remediated. Existing data does not indicate that a remedy should be selected. An ecological investigation and assessment will be conducted as a part of the selected remedy to more fully define the risk to the environment.

As stated in the response to the previous question, if remediation were necessary for Soldier Creek sediment or surface water, bioremediation would not be an appropriate treatment technology to select.

17. Comment:
I understand that is Tinker AFB's position. However, these chemicals were found in the surface water and sediment in the areas where children play. I am saying this without the benefit of looking at the values put in the risk assessment formula. I feel there is a concern with direct exposure.

Tinker AFB's Comment:
The assumptions and exposure scenarios used in the baseline risk assessment were conservative and the assessment was conducted following approved EPA guidelines. The baseline risk assessment concluded that an unacceptable risk to children, adults, and adult workers does not exist from Soldier Creek sediment and surface water. An ecological investigation and assessment will be conducted as a part of the selected remedy to more fully define the risk to the environment.

Commentator 1

18. Comment:
I would like to make a comment about the fact that there is no risk. Earlier I asked if sampling was conducted during periods of NPDES permit violation. If samples were collected on a day when there were no contaminants discharged to the creek, there would be no risk. But on a day a child might be playing in the creek and a permit violation is occurring, a health risk would certainly exist on that day.

Tinker AFB's Response:
Discharge from the IWTP, and any risks associated with releases of contaminants, is covered under Tinker AFB's NPDES permit. The sampling conducted as a part of the remedial investigation was to define the extent of sediment and surface water contamination in Soldier Creek. The releases that you are referring to are incidental and infrequent occurrences, and are not considered exposures when conducting a risk assessment. The releases represent an incidental exposure that does not represent an overall, long-term risk from Soldier Creek sediment and surface water. The long-term risk to human health and the environment is represented by the contaminants that are present in the sediment and provide a source of contaminants that feed the surface water. This type of risk, if it existed, would have been determined by the baseline risk assessment.

Commentator 3

19. Comment:
My family lives across from Building 3001. Nothing has been said of the chemicals that are absorbed through the skin during showering. We drink bottled water, but we are still taking showers.

Tinker AFB's Response:
We understand your concern. This investigation addresses sediment and surface water contamination associated with Soldier Creek. Groundwater contamination in the area of Building 3001 is currently being addressed through remediation. The groundwater in the area of Soldier Creek will be further investigated under the Soldier Creek Groundwater Operable Unit.

20. My children also play in Soldier Creek. How do you determine the effects of contaminants on skin?

    Tinker AFB's Response:
    During the baseline risk assessment, exposures scenarios were evaluated for dermal, or skin, contact from Soldier Creek sediment and surface water. Studies are conducted to determine the absorption rate of contaminants for both children and adults. The absorption rate data used in the baseline risk assessment was obtained from established and EPA-approved data bases.

Commentator 4

21. Comment:
    My primary concern is how long Landfill 6 has been in use. Were there any chemicals or industrial waste from that landfill detected in the samples collected during the RI.

    Tinker AFB's Response:
    There were sampling locations along the length of Soldier Creek in the area of Landfill 6. If contaminants were coming from Landfill 6 they would have been detected during the investigation. However, the focus of the RI was the sediment and surface water in Soldier Creek, not Landfill 6.

22. Comment:
    Does Landfill 6 have a sufficient containment system for early detection?

    Tinker AFB's Response:
    A cap was constructed on Landfill 6. The cap was built according to RCRA standards when designed and constructed. Landfill 6 is also surrounded by a monitoring well system that will enable detection of contaminant migration.

APPENDIX B

STATE LETTER OF ACCEPTANCE

The letter of acceptance will be added to the ROD when received from the State of Oklahoma.